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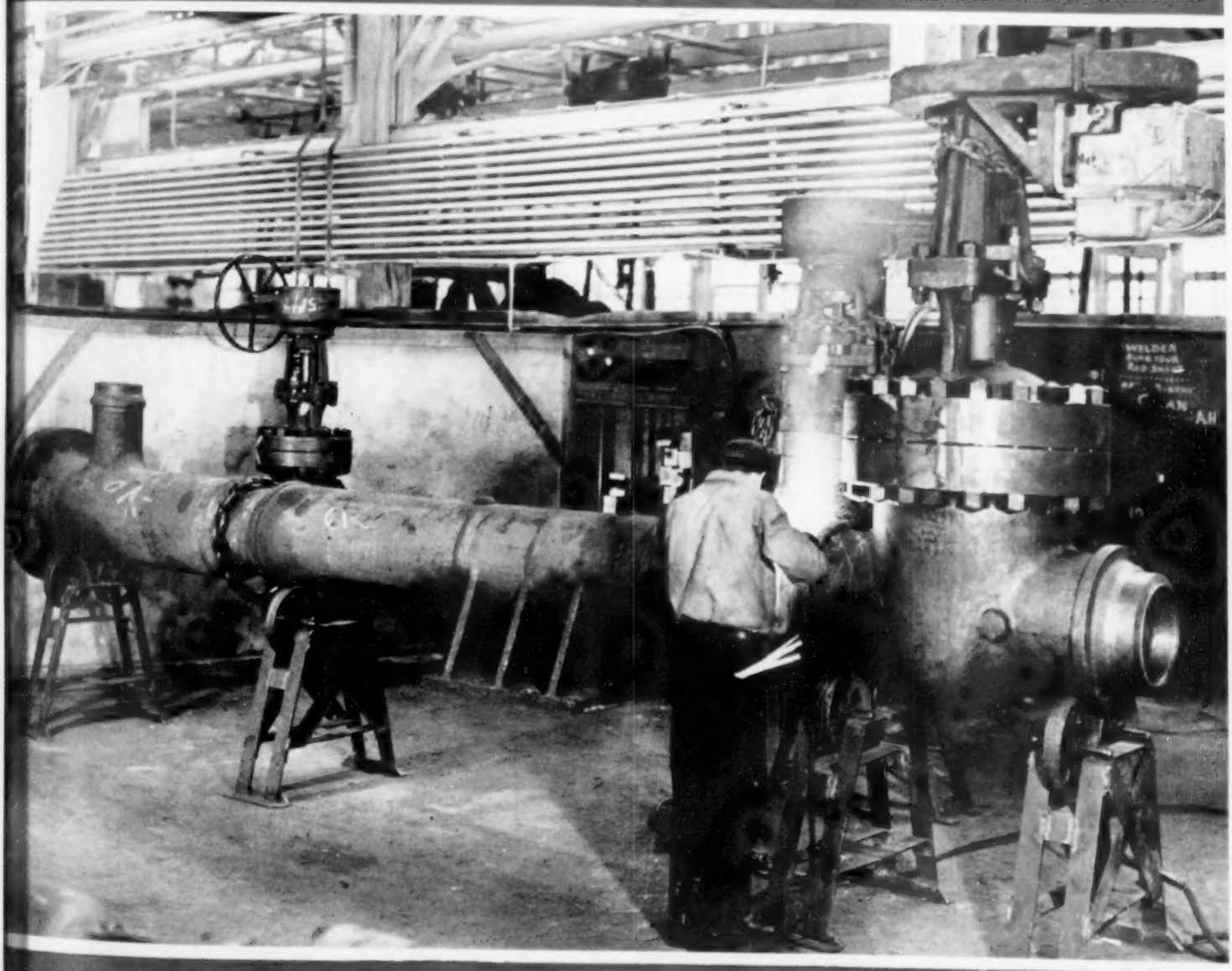
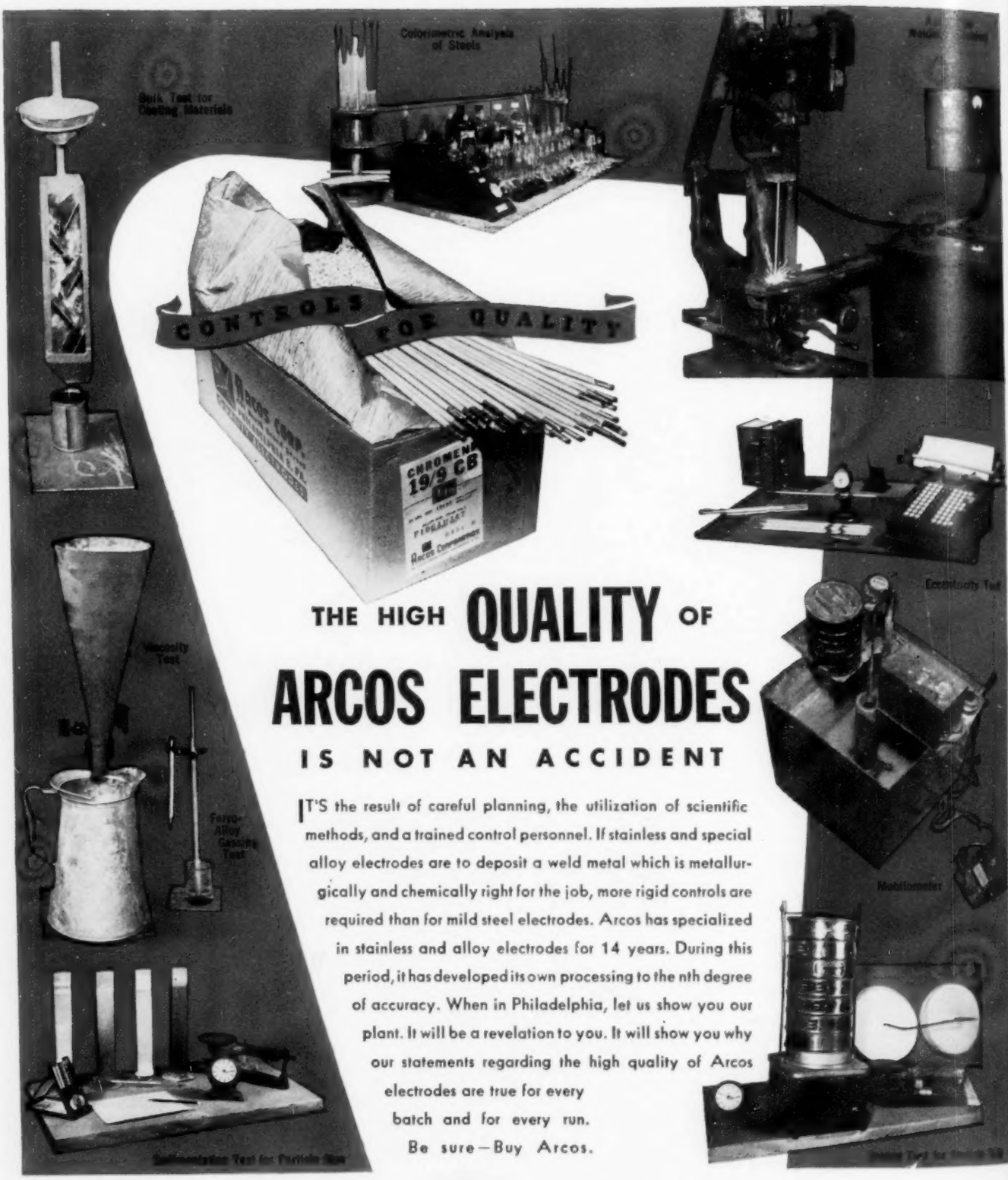
# The WELDING Journal



The Journal of the American Welding Society

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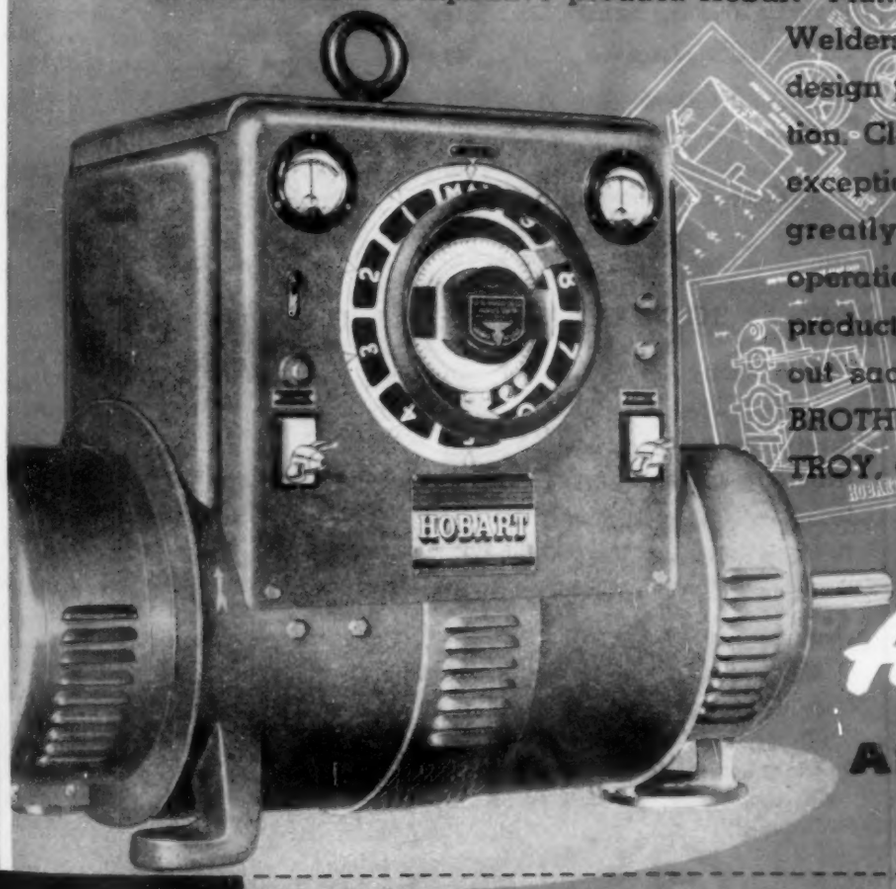


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# The Journal of the American Welding Society

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SEPTEMBER, 1945

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Welding Large Valve to Header.
*Courtesy of Crane Co.*

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# CONTENTS

## TECHNICAL PAPERS, ITEMS AND REPORTS

Quality Control During Production of Electric Resistance Welded Tubing, by Sidley O. Evans..... 805

Power for Welding, by L. W. Clark 811

Current Welding Literature..... 817

A Machine for Production Flame Cutting of Small Shapes, by E. E. Hart..... 819

Arc-Welding Engineering Problems and Engineers, by Walter J. Brooking..... 825

Resistance Welding Laboratories and Their Instruments, by R. T. Gillette..... 833

Machine Gas Cutting, by R. M. Dennis..... 839

Alloy Welding Wire from Powder Metallurgy, by F. G. Daveler and P. H. Aspen..... 842

## SOCIETY AND RELATED ACTIVITIES

1945-46 Officers, A.W.S..... 846

Vice-President Elect Dies..... 846

Board of Directors Meeting..... 846

**INDEX TO ADVERTISERS**..... 848

Dr. Wendell F. Hess Honored..... 852

Technical Societies Council..... 852

Welding Army's New Floating Aluminum Bridge..... 856

Electrode Chart..... 856

Murex Distributors..... 856

Lincoln Distributors Open New Office..... 856

American Bureau of Shipping Meeting..... 860

Flame-Cut Cinder Car Rack..... 864

Practical Design for Arc Welding—Vol. 3..... 864

New Power Take-Off..... 866

Ampco Issues Welding Technique Bulletin..... 868

Underwater Welding Photoed..... 868

All-Welded Circular Lifting Magnet 868

New Products..... 872

Theisinger Promoted..... 880

Annual Meeting Program..... 880

Section News..... 880

Employment Service Bulletin..... 880

## WELDING RESEARCH SUPPLEMENT

Metallurgical Factors of Underbead Cracking, by S. L. Hoyt, C. E. Sims and H. M. Banta..... 433-s

Weldability Tests of Valve Body Material, by Laurence H. Carr..... 446-s

Discussion of A. H. Cottrell's Paper "A Note on the Effect of Local Stresses on Mechanical Properties," by H. C. Boardman..... 452-s

The Effect of Hammer Blows on Welds Containing Cracks and/or Inclusions, by Elmer A. Ratzel... 455-s

Measuring Surface Resistance of Aluminum Alloys..... 458-s

The Journal of
The American Welding Society
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# Quality Control During Production of Electric Resistance Welded Tubing

By Sidley O. Evans*

THERE is no better guarantee of a uniform, strong, complete weld in resistance welded tubing than operation of the welding unit under such rigidly scrutinized control that it is never allowed to deviate from producing completely sound tubing.

Constant alert control is necessary even when the mill has been set up accurately and expertly, because wear and changes in strip characteristics may make adjustments necessary. Lacking this precise control, some tubing must be rejected as a sacrifice in the name of quality, but that sacrifice will injure rather than strengthen the confidence with which one may guarantee that the remaining tubing has a sound weld throughout its length.

Production control that deserves confidence can only result from a combination of perfected tests and experienced men—frequent tests performed at the welding machine designed specifically to detect minor maladjustments of that mill, and men whose experience enables them to interpret the tests accurately and correct the maladjustments before serious defects have been produced. This paper will deal with the tests performed at the welder which are helping the Welded Tube Division of the Babcock & Wilcox Tube Co. to maintain weld quality so consistently that the rejections resulting from couponing and hydrostatic testing each length of pressure tubing, have averaged less than 0.3% of the tubes tested month after month. The effectiveness of these tests depends not so much on the remarkable features of any one test as on the coordination of the group of tests to the characteristics of the mill.

## Essential Characteristics of Control Tests

The tests which control the quality of electric resistance welded tubing must have the following characteristics:

1. Scope—At least 10 or 15 ft. of tubing should be included in the test piece to assure the inclusion of defects that occur intermittently because of the tendency of a welding mill to precede serious continuous defects with widely spaced minor flaws.
2. Interpretation—The test or combination of tests should present sufficient evidence to reveal the seriousness, length, frequency and source of each difficulty so that appropriate corrections may be made.
3. Sensitivity—The greatest possible sensitivity is required. Even weld conditions that would not seriously affect the weld after normalizing, should be detected and corrected before the trouble progresses to the point where serious flaws occur.
4. Constancy—Probably the most important requirement of the test is that the sensitivity must be constant and not subject to the control of the operator. In any case where the operator may question whether a series of indications are the result of too high a sensitivity setting or the result of actual defects, he may make the wrong choice and reduce the sensitivity. Thus, if the yardstick of mill quality is flexible, it will be stretched just when it is needed most.

These four fundamental requirements imply other characteristics that are not specifically stated. For instance, the inspection of 10 or 15 ft. of tubing demands a nondestructive test because the expense involved in the frequent destruction of so much tubing would be prohibitive. As another instance, the requirement of high sensitivity would disqualify a test which would fail to detect a flaw having the depth of an inconsequential surface scratch near the weld. Consequently it is necessary that the test provide some way of distinguishing between the indications produced by these scratches and those produced by minor weld flaws. These implications and others may not be immediately apparent but certainly inject themselves forcibly in the course of a development of this nature.

## Choice of a Nondestructive Test

Magnaflux testing was chosen after an extensive investigation of the possible methods of nondestructive testing. Cold expanding of every foot of tube was found to be prohibitively expensive. X-ray inspection was slow and the ability to see the minor defects was limited. Hydrostatic expansion was limited by mechanical considerations. All known methods of electromagnetic flaw detection were carefully investigated, and those which would apply to magnetic steel were tested on tubing having defects ranging from incomplete welds to actual leaks. These methods were rejected for two reasons. First, no satisfactory working compromise was found between a degree of sensitivity that gave unnecessary indications, and a lesser degree that sometimes missed defects even as serious as leaks. Second, the sensitivity was at the mercy of the operator.

## Development of Methods

The magnaflux test was adopted only after an extended period of development, during which it was studied

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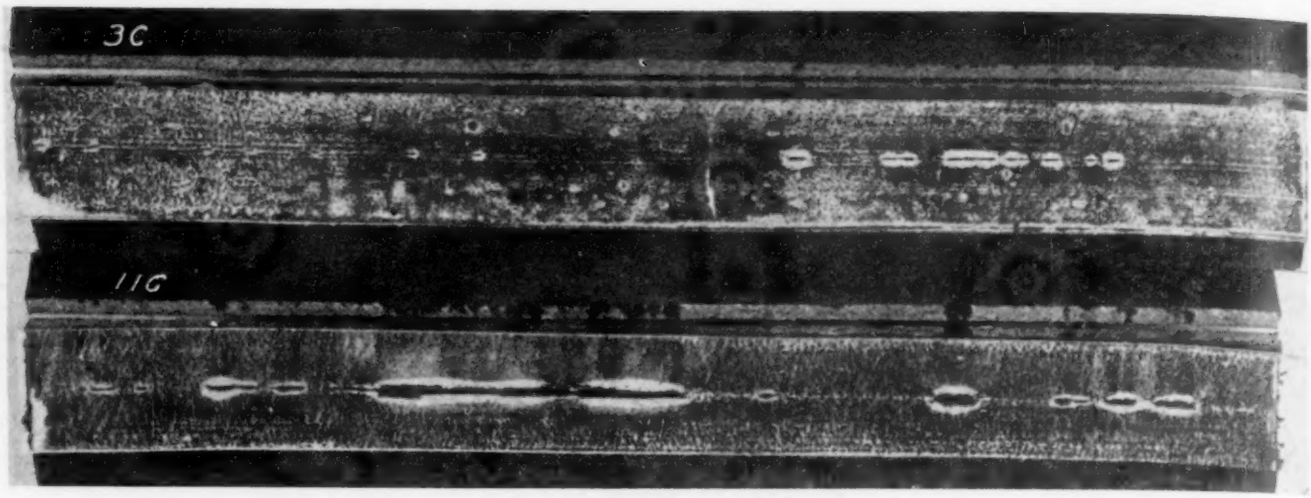


Fig. 1—Photograph Shows Two Specimens of Welded Tubing Which Had Been "Blued" and Then Broken Open at the Weld. Scotch Tape Impressions of Magnaflux Indications Are Shown Adjacent to the Broken Open Weld

carefully for limitations or "blind spots" and was adapted specifically for testing the weld zone of electric resistance welded tubing. Testing this material is somewhat different from the usual inspection procedure involving magnafluxing. In the first place, the inspection is limited to a very narrow zone around the weld line because the steel is inspected earlier in the manufacturing process. In the second place, it is desired to detect not only flaws of rejectable magnitude, but even the smallest imperfections so that the operating conditions might be corrected before conditions became serious. Finally, the mechanical and metallurgical conditions for $^1/_8$ in. on each side of the weld are such as to produce a very light magnaflux "background." This turns out to be an advantage in some respects and a disadvantage in others.

In view of the special nature of the job to be done, the development was undertaken with due regard to the wealth of magnaflux experience available but without limiting the experiments to the boundaries dictated by previous practice. In at least one case, it was possible to take advantage of a departure from normal magnaflux practice which resulted in greater sensitivity and greater ease of visual inspection in this inspection job, but is a disadvantage in normal magnaflux inspection.

The fundamental problems faced were: the choice between using a magnetizer, passing current through the

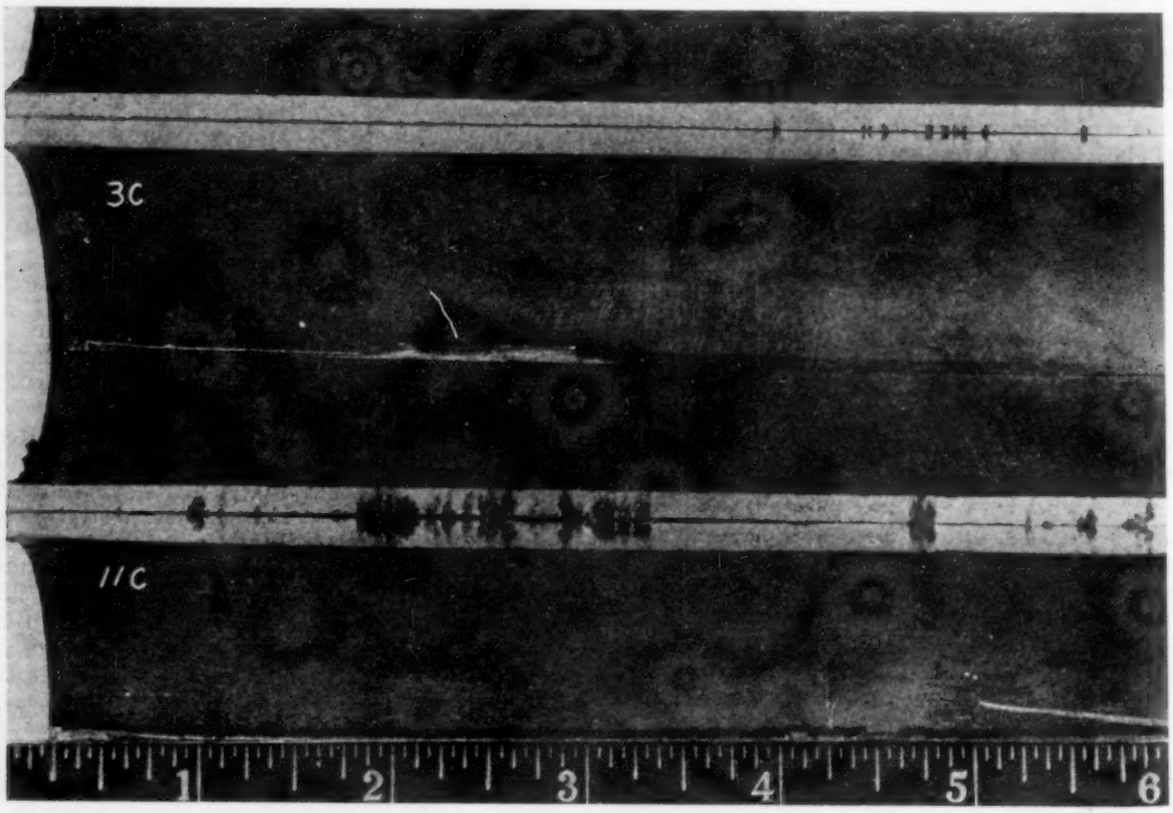


Fig. 2—Photograph Shows a Different View of the Same Specimens Depicted in Fig. 1. Here the Half Sections Are Mounted Back to Back and Show Clearly the Defective Areas in Both Halves of the Tube

tube wall, or passing current through a conductor inside the tube; the fixing of intensity of magnetization; the choice between wet and dry methods of magnafluxing and the fixing of the concentration of magnetic particles in the suspension. In addition to the fundamental choices, refinements of method were explored, including the kind of lighting best suited for inspection—both from the standpoint of direction of lighting and of the use of monochromatic light; the use of a magnifying glass to ease and speed inspection; and the removal of the magnaflux suspension from the tubes.

Many questions in the choice in magnaflux methods were settled on the basis of the ability to detect subsurface and inside flaws. Because magnetization by means of a copper bar inside the tube or by using a magnetizer gives more flux at the inside surface of the tube than magnetization by passing current through the tube directly, it should give greater sensitivity to inside defects. The dry method is more sensitive to deeply imbedded defects than the wet method because a subsurface flaw results in

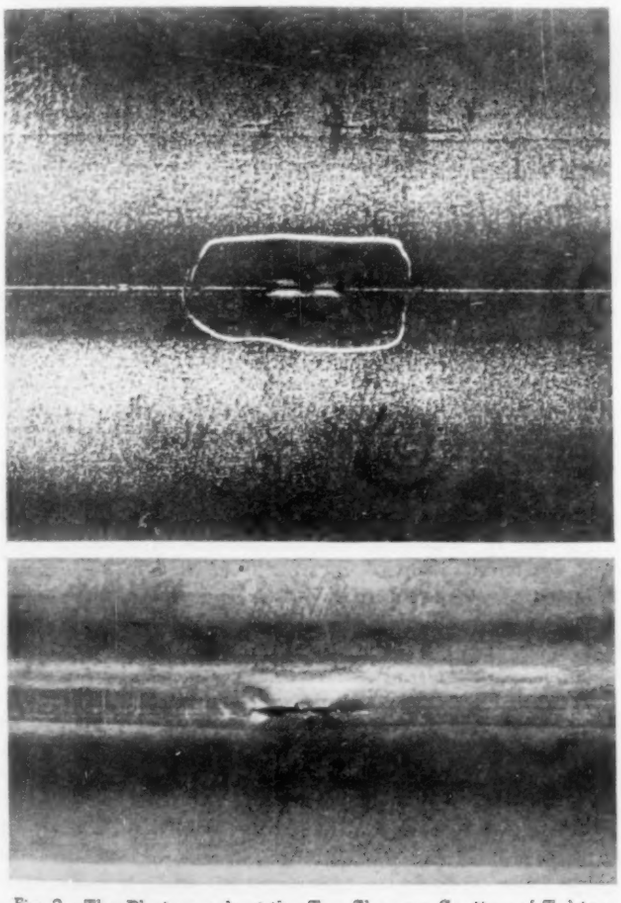

Fig. 3—The Photograph at the Top Shows a Section of Tubing Containing a Heavy Magnaflux Indication at the Weld. The Indicated Weld Flaw Opened up When Partially Flattened as Shown by the Photograph Directly Below

a broader, gentler disturbance of the magnetic flux than a fissure that comes to the surface. The magnetic particles used in the dry method, being larger than those used in the wet method, are more affected by this broad disturbance. If the use of an inside bar for magnetizing and use of the dry method had detected inside defects, it would certainly have been adopted; however, repeated attempts to detect inside flaws using these methods were unsuccessful. Possibly this was due to masking of the indication by the magnetic discontinuity near the weld line, or possibly the flaws were too small to be detected at that depth. In any case, no indication which was sufficiently distinct so as to be reliably interpreted

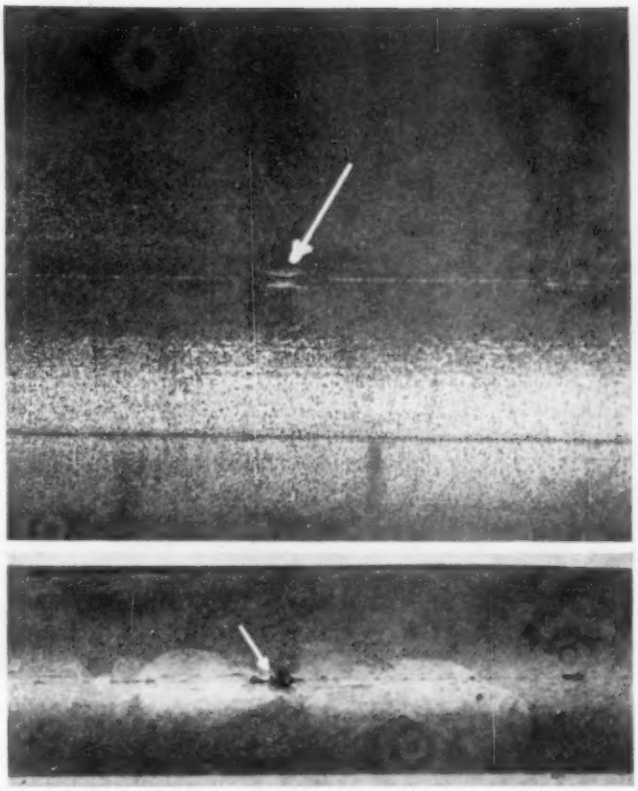

Fig. 4—The Photograph at the Top Shows a Section of Tubing Containing a Medium Magnaflux Indication. When This Section of Tube Containing the Indication Was Partially Flattened, the Weld Flaw Opened Up as Depicted by the Photograph Below. The Weld Defect Opened up Regardless of the Fact That the Tube Section Was Normalized Prior to Flattening

by an inspector appeared regardless of which method was employed. This limitation necessitates supplementing magnaflux testing with a test which is especially sensitive to inside defects. This will be discussed later.

Once the inability to detect inside defects was ac-

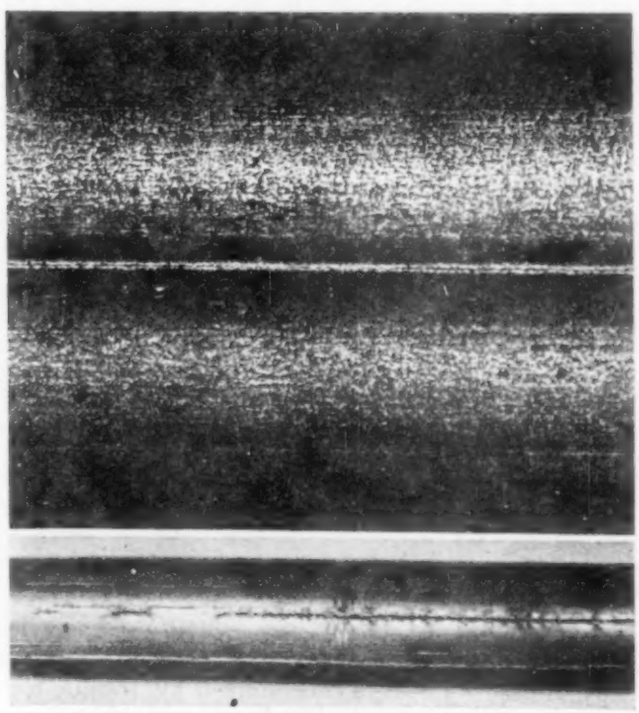

Fig. 5—The Photograph at the Top Shows a Section of Tubing Containing a Light Continuous Magnaflux Indication at the Weld. The Flattened Section Is Shown Below

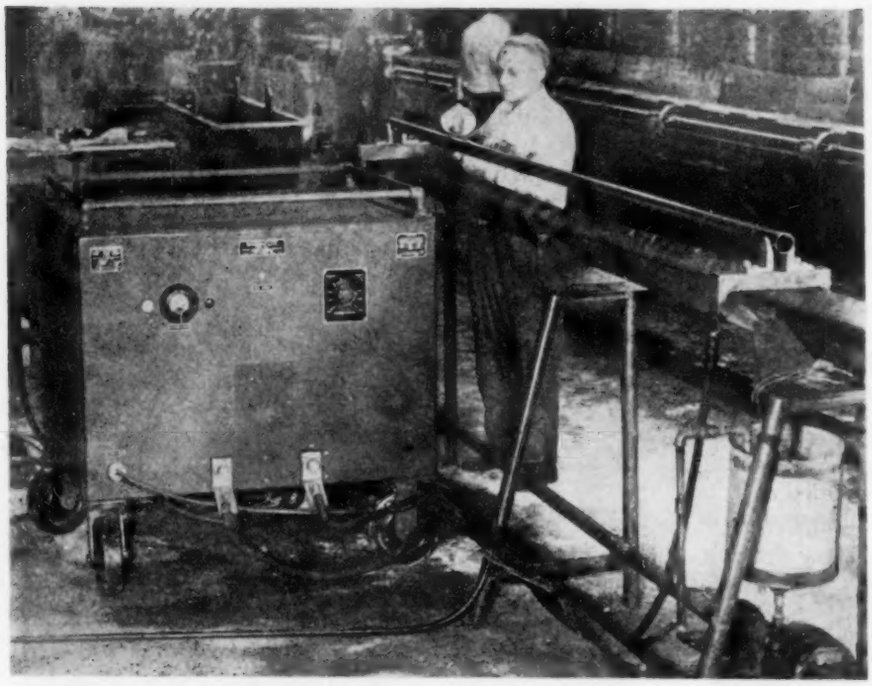

Fig. 6—Magnaflux Testing at the B & W Welding Mill

cepted, the choice of procedure was based on ease of operation and sharpness of those indications which could be detected. For the inspection at the mill use of current through the tube wall with the wet method was adopted.

It was in the choice of magnetic particle concentration in the magnaflux suspension that advantage was taken of the peculiarities of this application. The best and most easily inspected indications resulted from a particle concentration, as determined by allowing a demagnetized sample of suspension to settle in a centrifuge tube, of two to three times the values normally used. However, since only the weld area is to be inspected, and since the magnetic discontinuity around the weld prevents a heavy background in this area, inspection is not handicapped by the heavy background that would usually result from so heavy a concentration. Furthermore, since it is desirable to catch and correct even the smallest defect, the added sensitivity is an advantage, instead of being a hindrance as it would be in the usual case where indications resulting from defects of less than rejectable magnitude would be a distraction.

The intensity of magnetization which produced the most satisfactory indications was found to be about 400 amp. per inch of diameter. This value of current is common in magnaflux practice.

The most important characteristic that remained to be determined was the correlation between flaw size and indication size. While it was already an accepted fact that inside flaws could not be detected by this method, this did not eliminate magnaflux as part of a test procedure, but merely meant that it must be supplemented by other tests. However, if the sensitivity of this test were to depend on the arbitrary judgment of the operator who might assume that the sensitivity was too high when the mill was actually in trouble, this test would be useless as a yardstick of mill quality even for those defects which it could detect.

To be sure of correlation between magnitude of the indications obtained and severity of the flaw present, a large number of samples were tested including tubes that had been rejected in couponing or hydrostatic test. Magnaflux indications were lifted and recorded by means of cellulose scotch tape and were classified as "light," "medium" and "heavy." Specimens containing representative defects were then treated in a chemical bluing solution at about 280° F. for several hours. This allowed time for the solution to penetrate to the bottom of the defect (fissure) leaving its area coated with a blue oxide. Since long-time immersion in the solution at elevated temperature results also in age hardening and notch sensitivity of the metal, the flaws forming a notch at the weld made it relatively easy to break the specimen along the weld line in order to examine the actual dimensions of the defects. An example of a typical lifted indication and blued specimen is shown in Fig. 1.

Two samples are shown with the scotch tape impression of the magnaflux indications placed adjacent to the broken-open weld. The correlation between relative heaviness of lifted indication and severity or depth of defect is obvious. Figure 2 gives another view of these same blued specimens. In this case the tube sections are mounted back to back showing the defective areas in both halves of the tubes.

The correlation found to exist between indication size and defect size was very good, as is shown by the examples in the illustrations. In all cases, a light indication meant a flaw less than $^1/_{32}$ in. deep; a medium indication meant a flaw $^1/_3$ to $^1/_2$ way through the wall; and a heavy indication meant a flaw either completely or almost completely through the wall.

In addition to the study of what indications meant in terms of flaw depth, a study was made of the significance of various indications in terms of the severity of failures when the tube is deformed by flattening in either the as-welded or normalized condition. Three examples are shown in Figs. 3, 4 and 5. Again the correlation between magnitude of indication and seriousness of defect is striking. From observation of many tests, it can be stated that the heavy defects will open up on flattening under a relatively minor amount of deformation, whereas, the lighter require greater deformation on flattening before opening of the weld at the defective area of areas.

The only operation variables that can affect the correlation between size of indication and severity of flaw are the value of current passing through the tube during magnafluxing and the concentration of magnetic particles in the suspension. Consequently, the standard current value to be used for each size of tubing has been determined and is posted at the equipment, and the Laboratory makes periodic tests of particle concentration using the centrifuge tube method. As a result of these precautions, any indication on the surface not only betrays and delineates the weld defect, but also tells its depth and extent, so the operator can base his judgment of what steps to take in adjusting the mill on complete information regarding these defects.

The magnaflux equipment, shown in Fig. 6, consists of a type K Q-3 rectifier, 3000 amp. capacity, manufactured by the Magnaflux Corp., connected to tapered electrodes. Wedging action between the tapered faces makes firm contact with a tube laid between the electrodes so that no clamping is necessary. To test a tube, it is merely necessary to lay it between the electrodes, push a button to turn on the current, apply the liquid and inspect. This is done easily and rapidly by a trained operator at the mill. A trough returns the excess liquid to a sump where a circulating pump is provided

to prevent the magnetic particles from settling out.

In view of the quantitative indications yielded by magnaflux testing and the ease with which it can be applied to long tubes, the question naturally arises as to why any further test should be used. The answer to this lies in the inability of magnaflux to detect very small subsurface or inner surface conditions. Two such conditions were found and a test was provided for each. To see how magnaflux plus the two supplementary tests combine to give complete coverage of mill trouble, each area of mill trouble will be outlined with a description of the test that throws a spotlight on that area.

Minute eccentricities occur in the various rolls of the mill as it is set up even when the greatest care and skill is used. As these coincide and diverge, they give the mill a "pulse" that can be seen in the welding current or electrode pressure and can be recorded by oscillographic measurement. When the welding heat current is not properly adjusted, the minimum value of current during the pulse may be below the point where a complete weld occurs. The result will be a short length of incomplete or faulty weld for each pulse. Magnaflux testing is very sensitive to this type of fault. Since the flaw may be a few thousandths of an inch long and occurs only once in 5 to 15 ft., a magnaflux test of a long piece is most satisfactory, since it yields a maximum amount of information on the extent, frequency and severity of the flaws.

Another kind of trouble occasionally encountered, results from wear of one roll in the forming mill. When such wear occurs, the flaw condition of the weld develops very slowly. In the course of this development, the weld goes from perfect to a condition which will cause it to fail in flattening in the as-welded state but stand the flattening test after normalizing, and finally to a condition which will cause it to fail even after normalizing. In the early stages of development of trouble from this source, magnaflux testing is helpless to detect anything wrong because breaking will occur in the as-welded condition even before any definite flaw can be seen by microscopic examination. Even later, when the shape of the abutting edges has deteriorated to the point where the flaw may be an entrapment of foreign material of only

Fig. 7—Photomicrograph Shows Submerged Oxide Inclusion Resulting from Roll Wear

0.015 in. extent submerged 0.010 in. below the surface, the magnaflux method still will not detect it satisfactorily because a sufficient flux path exists to bridge the defective area. Consequently it is necessary to perform magnaflux tests alternately with flattening tests.

The result of the roll condition is shown in Figs. 7 and 8. Measurements made on the photomicrograph in Fig. 7 indicate that the dimensions are those mentioned above. The flattening failures which result from the flaw are shown in Fig. 8, with the as-welded specimen on the bottom and normalized specimen on the top. This photograph affords a striking comparison between the very noticeable failure in the as-welded condition and the flattening almost without any failure in the normalized sample.

Fortunately, as shown in Fig. 8, the flattening test is very well suited to catch this condition. In the first

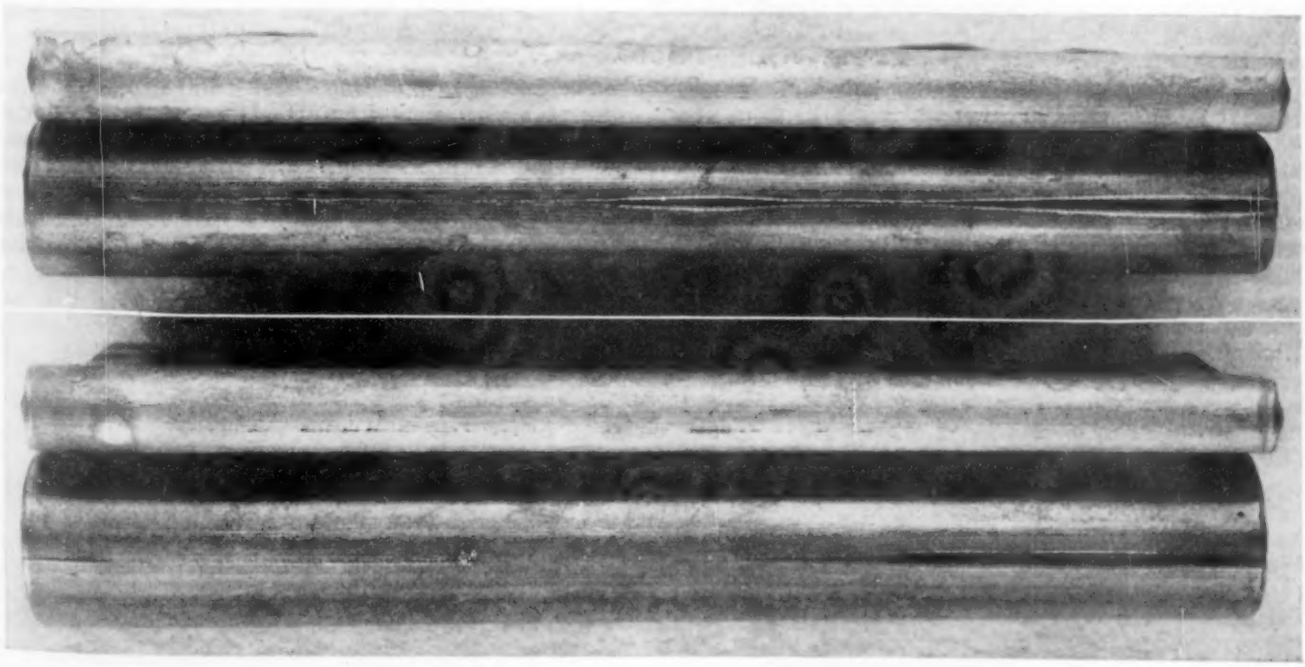

Fig. 8—Photograph Shows Flattening Failures Which Resulted from the Kind of Flaw Depicted in Fig. 7. The Specimen at the Bottom in Each Pair Was Flattened in the "As-Welded" Condition While the Ones at the Top of Each Pair Were Normalized Prior to Flattening

place, the notch sensitivity of the as-welded material makes it possible to detect this condition before it has progressed far enough so as to affect the ability of the normalized tube to stand flattening. Thus the test actually anticipates the occurrence of defects in the normalized tube and, since the roll wear and resulting trouble develops gradually over a period of hours, there is ample opportunity to rectify the condition before any tubing is produced which would show defects in the normalized state. In the second place, the trouble is due to a specific roll so that the flaws caused by it will be spaced only a few feet apart and may be caught quite easily.

An interesting sidelight on the combination of the results of magnaflux and flattening tests is the reaction of the operators to a flattening failure with no magnaflux indication. They immediately know what changes to make, and in every case so far, these changes have corrected the difficulty. The combination of these two tests not only gives complete coverage of the possible outside flaws, but also makes possible a diagnosis of the trouble.

A third kind of trouble occurs when the mill is being set up and the positional adjustments of parts of the mill are incorrect. This will result in a weld which has a very small opening at the inside (split bead). As mentioned before, these defects do not yield a magnaflux indication which may be satisfactorily determined by inspection.

Fortunately again, this defect is easily caught by destructive testing. The flare test on the as-welded tube is very sensitive to it, and since the condition has been found to be persistent, it is quickly detected and the necessary adjustments are made.

Figure 9 is a photomicrograph of the weld taken at the inside surface of the tube, showing this type of flaw. Although the radial dimension of the flaw shown is very small, it will be detected by the flare test.

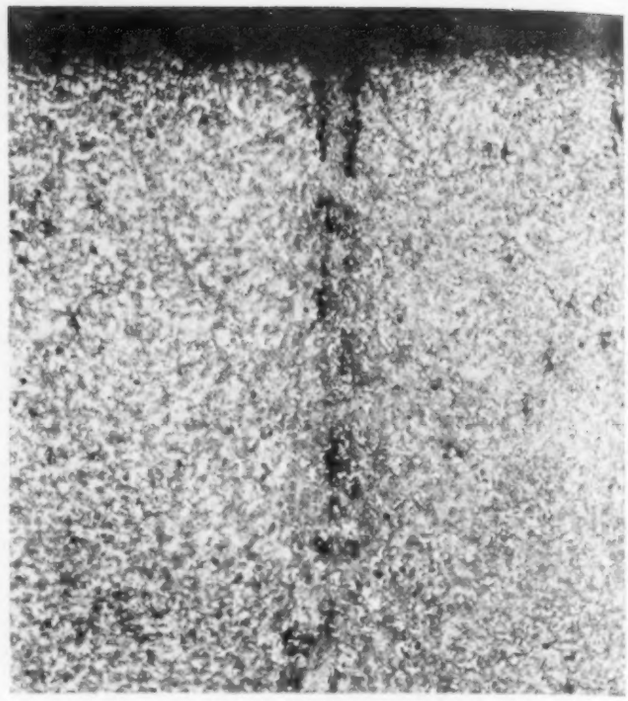

Fig. 9—Shows Flaw at the Weld on the Inside Surface of the Tube

## Conclusions

As the result of these studies, the testing procedure adopted consists of magnafluxing and flatten-flare testing alternate specimens off the mill. The magnaflux test inspects a long piece of tubing so that it covers at least one complete "pulse" of the system and catches all defects caused by that pulse. The flattening test on the notch-sensitive as-welded material provides an ultra sensitive test for the condition which results from wear, so that it will detect the condition before it has become a defect in the normalized tubing. The flare test catches the inside defects which may occur during setting up the mill as the result of the electrodes and squeeze rolls of the welder being out of mechanical adjustment. Each of these three tests have "blind spots" if used alone, but the blind spot of one is the specialty of the next, and together they envelope the full range of possible mill trouble. Furthermore, they are so coordinated to mill operation that, by noting the relative indications of the three, in most cases it is possible not only to detect mill trouble, but also to diagnose and correct the trouble immediately. The result is that the detecting, diagnosing and correcting of trouble are accomplished quickly and the quality of the tubing leaving the mill is maintained at a uniform level so high that the rejections on the acceptance tests are altogether negligible, and there is no fear of what the acceptance tests may have missed.

## Acknowledgments

The author acknowledges the helpful comments and suggestions received from H. D. Newell, Director of Research, during the course of this development, and the very helpful assistance given by Z. E. Olzak, Research Assistant, in working out the details of the method of quality control described in the paper. Also, for the cooperation of the personnel of the Welded Tube Division, Alliance, Ohio.

# Power for Welding

By L. W. Clark†

MOST of the talks presented before our local section of the AMERICAN WELDING SOCIETY abound with such familiar welding terms as depth of penetration, heat-affected zone, austenitic steel, dendritic formations and others. If any of you here tonight are expecting such a discourse you are going to be disappointed. I do not expect to use any such terms and, furthermore, if any technical terms are needed they will be simple—simple electrical terms. In fact, I think three—amperes, ohms and volts—should be adequate for presenting this discussion of power supply for resistance welders.

In case there are some of us here who are not too electrically minded, it may be well to digress for just a moment and compare an electrical system with the common and perhaps more familiar water system. In a water system the water flow is measured in terms of gallons of water per minute, whereas in the electrical system the current flow is measured in terms of amperes. Similarly, the water system has a certain size pipe, the diameter of which affects the resistance to the flow of water, whereas the electrical system has a conductor through which the current is flowing and which presents a certain impedance (measured in ohms) to the flow of that current. The water system has pressure behind it tending to force the water through the system and this pressure is expressed in terms of pounds per square inch, whereas in the electrical system the pressure behind the flow of current through the ohms impedance of the system is expressed in volts.

The electrical load of a large resistance welder is usually one of high magnitude, extremely short duration, intermittent in character, single phase and often of low power factor; and by a load of high magnitude, I mean a load as great as 1000 kva. to 3000 kva. To give you a better idea of just what this means, we can point out innumerable plants employing hundreds, and in some cases thousands, of men, whose entire electrical plant requirements do not exceed 2000 or 3000 kva., while here we have a single machine that has the same maximum load, but on an intermittent, short-duration basis. Is it any wonder that, at times, difficulties have been encountered in providing adequate power facilities for loads of this type?

## Lamp Flicker

From the standpoint of the power company the problem of serving a welder is basically that of carrying the fluctuating load without creating objectionable lamp flicker. The lamp flicker due to a welder operation is caused by the voltage drop in the supply system due to the amperes flowing to the welder over the impedance of the system. If the voltage dip exceeds certain limits the resultant lamp flicker will be noticeable and objectionable.

I am sure you have all seen instances of lamp flicker, probably in your own homes. In many cases there is a slight dip in the lights when the refrigerator starts, the electric oven goes on, or perhaps the washing machine is started in the basement. Most of us pay little attention to it because we know it is our own equipment and house wiring that is the cause of the lamp flicker, but if this were to occur frequently from some unknown outside cause, most of us would complain about it to the power company. Light flicker troubles on an electrical system can be compared with shower bath troubles in connection with the average household water system. How many times have each of you settled down to an enjoyable shower bath when someone down in the kitchen opens the hot water faucet? The water turns cold and before the shower can be readjusted, the hot water is turned off again in the kitchen. On the electrical system the lights correspond with the shower and the welder with the use of water in the kitchen, and in both cases the supply conductor or water piping, as the case may be, must be adequate if the one use is not to disturb the other.

Thus, the problem of supplying service to a welder is primarily one of connecting the welder to the supply system at some point where the impedance of the system is low enough so that the welder does not cause the lights of lighting customers fed from that portion of the system to flicker. Resistance welders can cause two types of lamp flicker. Single impulse machines such as spot, butt, flash or projection welders can cause noncyclic flickers that are usually repetitive in nature but follow a sort of hit-and-miss pattern with no degree of regularity. Seam welders or spot and projection welders equipped with pulsation control can cause cyclic flickers that recur in rapid succession with fixed regularity.

### *Noncyclic Flicker*

Noncyclic flickers that recur at irregular but fairly frequent intervals, as is the case when caused by welders, are usually objectionable to most people if the lamp voltage drops more than 2 volts. There are a great many factors affecting the setting of this value as a permissible limit, such as size of lamp, type of lighting, sensitivity of different individuals, number of individuals affected, frequency of occurrence, presence of noise in the surroundings, etc., and so, while in general a 2-volt limit is permissible, there may be cases where it can be raised to 3 volts or it may have to be lowered to 1 or $1^1/_2$ volts. In some borderline cases where complete correction would require a large investment, it may prove desirable to have a trial test installation set up before finally approving the job.

### *Cyclic Flicker*

Cyclic flickers, which recur at regular intervals, become evident and may prove objectionable whenever the rate exceeds 1 flicker per second. Here the borderline of objection follows a typical "V" curve, as shown in Fig. 1, dropping to a minimum of about $^1/_2$-volt at the worst frequency of 7 or 8 flickers per second. Many seam welders

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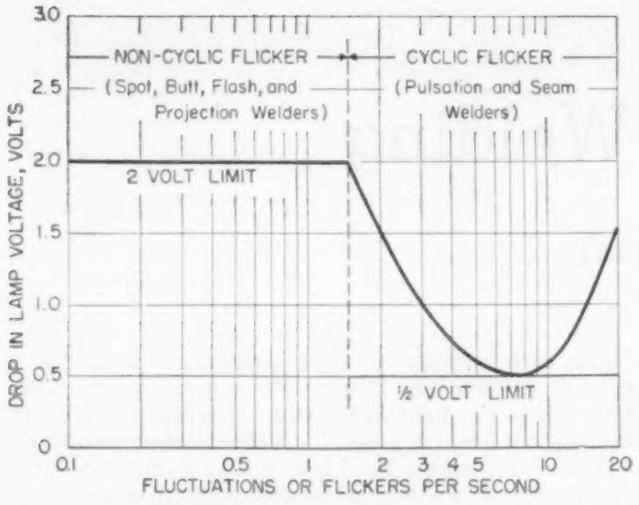


Fig. 1—Permissible Limits for Cyclic and Noncyclic Flicker

operate at frequencies of from 1 to 4 cycles "on" and from 1 to 4 cycles "off" which is right in the cyclic range. Similarly, spot or projection welders equipped with pulsation control to give a series of current pulses (so many cycles "on" and so many cycles "off") may produce lamp flicker in the cyclic range.

Even if the frequency of a specific pulsation weld is fairly high up on either side of the "V" curve it is quite likely that some time during the life of the installation the control will be changed and welds made at the worst frequency of some 7 or 8 pulses per second. Such a change in the frequency of pulsations can be easily made by a simple turn of the control dial and so bring the operation anywhere within the entire range of cyclic flicker. For this reason, where either seam welders or spot and projection welders with pulsation control are concerned, it is usually necessary to design the welder service so as to stay within the $^1/_2$-v. limit. Again this $^1/_2$-volt cyclic flicker limit must not be considered as exact and it may be adjusted slightly upward or downward as conditions dictate.

The pulsations or interruptions are an accepted part of most seam-welding operations and it is claimed by some that it is necessary to utilize pulsation welding for certain difficult spot and projection welds. Sometimes the argument is also advanced that by adding pulsation control it is possible to make a given weld at a greatly reduced kva. demand. Obviously if by so doing the demand is not reduced in a ratio greater than 4 to 1, it is seldom that anything has been gained as far as effective reduction in lamp flicker is concerned and it is unusual when a reduction in demand of that much can be had by resort to pulsation welding.

## Early Welder Trouble

I would like to go back to the early thirties and tell you of our first experience with a really big welder. A large plant on the east side of Detroit installed a welder which had a maximum kva. demand of some 4000 kva. and our first knowledge of the operation of this welder was through flicker complaints that originated in a large residential area served from the same substation that served the plant. If you remember the conditions back in 1931 and 1932, you will recall that business was poor and as a result of this the load on the substation was not particularly large. We were thus able to temporarily divide the substation into two parts and pick up the welder on one-half of the substation and serve the lighting load of the area on the other half. This was a large substation, representing an investment of some $900,000, which meant that quite a sizable investment was tied up in providing service to a single machine. However, this permitted production to go on while the welder manufacturer designed and built a new machine that could do the same job with about one-third the disturbance effect on the system.

It was then possible to serve this new machine along with other welding load with only one bus section in the substation segregated from the lighting load, rather than the entire half of the substation. I believe this was the first instance of establishing what we now call a "flicker bus" in a substation for serving fluctuating loads. Since that time, similar bus sections have been set aside in other substations for handling this type of load, always with the reservation that should the substation load increase to a point where all bus sections would be needed for the so-called good or nonfluctuating loads, we might be forced to ask the customer to put in corrective equipment so that the welders could be handled on regular bus sections along with lighting loads. Fortunately, however, this has not yet been necessary, due to the fact that as the so-called good load grew, so did the total of the fluctuating load and, in fact, it has been necessary in one case to set aside two bus sections as "flicker busses" in a single substation because of the rapid and substantial growth of the fluctuating type of load.

## Welder Operation

Now let's look at the problem from the standpoint of the welder itself. Again it is simply a matter of amperes, ohms and volts. It is necessary to keep the voltage at the welder within certain limits and not have too great a voltage drop when the amperes drawn by the welder flow over the impedance of the supply system. Fortunately the welding machine is not as critical as lighting when it comes to voltage changes and we can permit considerably more voltage drop at the machine itself than can be permitted on the system where lighting customers may be affected. The greater portion of this additional voltage drop will be in the stepdown transformers and low voltage feeder circuits in the plant. If there is only one machine on a plant circuit and there is a sufficient range of taps on the welding transformer it is sometimes possible to make the weld with 20, 30 and in some cases as much as 50% voltage drop. However, this is not to be recommended, and when there are two or more machines on a common circuit, it would be impossible to get consistently good welds with any such voltage drops, due to the probability of machines "hitting" at the same time.

Where there are not more than five or ten large machines on a given circuit, and the material being welded is ordinary low-carbon steel with no unusual welding requirements, I would say that we had exceptionally good voltage conditions if the current drawn by the largest machine did not pull the voltage down by more than 5%; and reasonably good conditions if the drop did not exceed 10%. Different types of welding and different types of machines may require different limits but, in general, a 10% value represents a reasonable design limit to work to.

If we divide the supply system into three parts, we have: first, the utility power system—the incoming lines up to the customer's plant; second, the stepdown transformer bank; and, third, the low voltage bus or feeder leading directly to the machines, over all of which this total of 10% drop can be divided. The first step in providing service to a welder is to find out from the power company representative how much drop the welder will cause in the utility lines. This is important on two

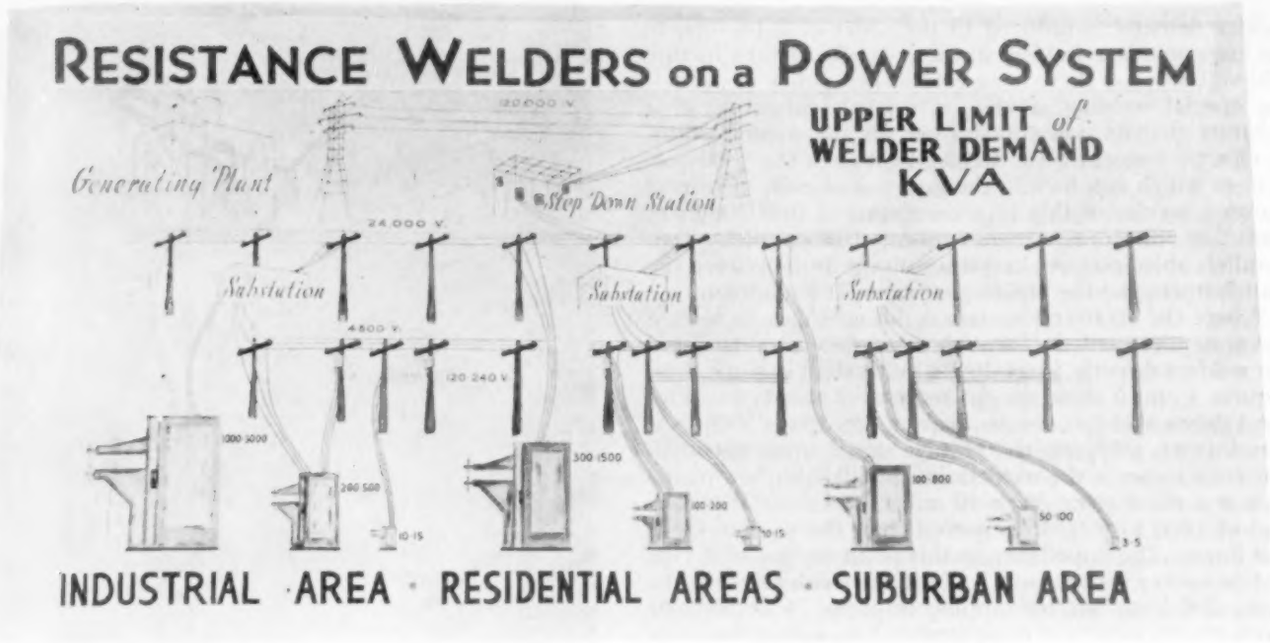


Fig. 2—Resistance Welders on a Power System

counts: it not only gives a start in the design of the welder supply, but it also gives the utility engineer a chance to check the possible flicker effect on other neighboring customers. I cannot emphasize this point too strongly—always check with the power company before buying a new welder.

### The Utility System

In discussing the power company's portion of the supply facilities, I would like to refer to Fig. 2. This shows, in a very general way, the over-all range of welder demands that can be handled on the several portions of The Detroit Edison Company power system without causing objectionable lamp flicker. No two power systems are alike and it should not be inferred that either the range of demands indicated or the locations referred to would apply to power systems in general.

Starting at the upper left-hand corner of the chart there is a generating plant which feeds both a 120-kv. tower line and a 24-kv. transmission line. Actually there are four such generating plants tied into the system at either or both of these high-voltage levels. The 120-kv. tower line surrounds the greater Detroit area and along the way there are several stepdown stations feeding the 24-kv. system. The 24-kv. lines extend throughout the entire territory except for one outlying district where the voltage is stepped up to 40 kv. Industrial and distribution substations step the voltage down from either 24 kv. or 40 kv. to 4800 volts and distribution transformers located near the loads step it down still further to 120/240 volts. The 4800-volt and 120/240-volt wires are those which we see in the alleys and easements back of our homes. They provide service to the residential and small commercial loads. If this were an equivalent water system we might show the 120-kv. tower line as, say, a 6-ft. main, perhaps the 24-kv. line as a 2-ft. main, the 4800-volt lines as 8-in. pipes and the 120/240-volt lines as half-inch pipes.

Thus in going from the top of the chart to the bottom, in other words from the higher to the lower voltages, the impedance of the system increases very materially just as the resistance to the flow of water increases for the smaller pipe. Similarly, in going from left to right on the chart which simulates getting farther from the power source at any given voltage level, the impedance again increases.

Where the impedance of the supply system is low, that is, near large sources of power such as generating stations, or large stepdown substations, large welders are easily served without exceeding the predetermined flicker limit. It is obvious, however, that as the impedance becomes greater either through stepping down to a lower voltage part of the system or through adding miles of line at any given voltage, the size of welder that can be handled without exceeding the flicker limit becomes smaller and smaller.

In the case of large plants served at 24 kv. in established industrial areas, there is practically no problem as far as large welders are concerned. The welders can be connected right in with the rest of the plant load. Other large plants that may be served at 4800 volts, even in the same general location, cannot ordinarily handle as large welders because of the greater impedance at the lower voltage level. Here it is sometimes possible, as previously mentioned, to connect a 4800-volt line serving only the one customer to a "flicker bus" in a 24,000/4800-volt distribution substation. Since there are no lighting customers on the "flicker bus" the permissible welder demand is limited only by its affect on the 24-kv. system so that whether the plant is served at 24 kv. or from a 4800-volt "flicker bus," resistance welders with kva. demands of the order of 1000 kva. to as high as 3000 kva. can readily be handled, as shown at the lower left corner of the chart.

For the smaller plants in the industrial areas that are served in common with other customers from 4800-volt lines, if one is not to disturb the other, the permissible welder demand must be reduced to values of the order of 200 to 500 kva. For similar plants in residential areas, away from the large stations, the size of welder that can be handled even on the 4800-volt lines is reduced to the order of 100 to 200 kva. Still farther out in the suburban area, the 4800-volt lines can accommodate welder demands in the range of only 50 to 100 kva.

For the still smaller plants anywhere on the system that are served from the 240-volt lines, the permissible

welder demand is reduced to the order of 5 to 15 kva. To accommodate welders in these smaller plants, having 240-volt service, there is an established policy of providing special welding service, if needed, consisting of a separate distribution transformer for the welders, thus, in effect, connecting the welder load onto the 4800-volt system which can handle the larger demands. Figure 3 shows a service of this type consisting of four 100-kva., 4800/240-volt transformers connected in parallel. Two parallel cabled services keep the voltage drop between the transformers and the building entrance at a minimum.

Where the 4800-volt system is not adequate to meet a given requirement, it then becomes necessary to serve the welders directly from the 24-kv. system in some way. Figures 4 and 5 show special services of this type. Figure 4 shows a 24-kv., single-phase tap feeding a 1000-kva. transformer, stepping the voltage down from 24,000 to 240 volts to serve the welders in a small suburban plant. This is a plant some 30 or 40 miles from Detroit with a load of 1500 to 2000 kva. served from the regular 4800-volt lines. The impedance at this point on the 4800-volt system makes it necessary to limit the welder demand to about 200 kva. but by tapping into the 24-kv. system where the impedance is considerably less, welder demands of 800 kva. can be permitted. Figure 5 shows a 24-kv. tap station consisting of a 1000-kva., 24,000/480-volt

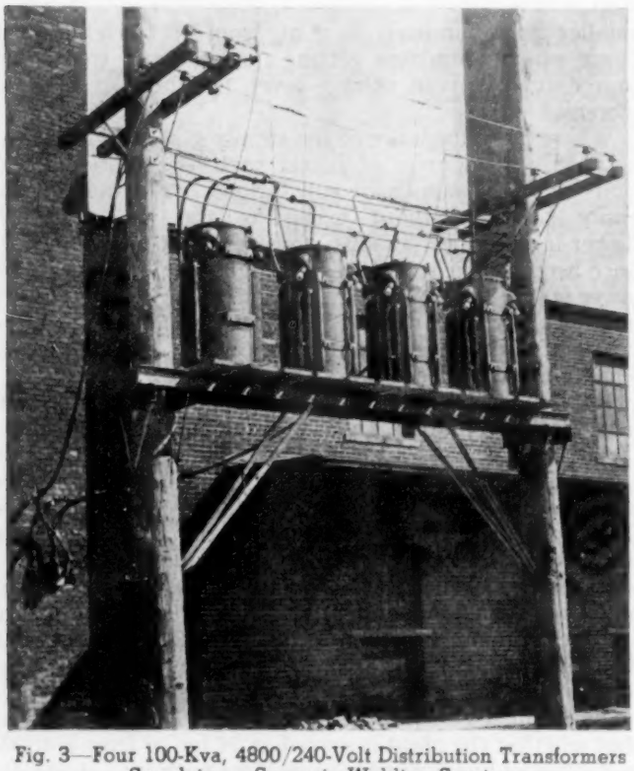

Fig. 3—Four 100-Kva, 4800/240-Volt Distribution Transformers Supplying a Separate Welding Service

transformer with an underground feed, pole-top switch and fuses, serving the welders in another small plant in an outlying semi-residential district where the 24-kv. lines are carried underground. This plant is relatively small and gets its normal service from the 240-volt lines.

## Stepdown Transformer Banks

The second part of the welder supply system is the stepdown transformer bank on the customer's premises or in his plant. The primary considerations here are those of impedance, size and location of transformer bank. The transformers should be of low impedance, adequate size and located as close to the welding operations as

Fig. 4—Welding Substation, 1000 Kva., 24,000/240 Volts Single Phase

practicable. For those interested in the technical details in regard to both the transformer bank and secondary bus and feeders I would like to refer to an A.I.E.E. Committee Report, "Power Supply for Resistance-Welding Machines, Part III, Factory Wiring for Resistance Welders." This report gives complete information on how to

Fig. 5—Welding Substation, 1000 Kva, 24,000/480 Volts Single Phase

select the proper size of transformers and how to design the low-voltage bus and feeders.

Any discussion of the stepdown transformer is certainly not complete without taking up the question of single-phase vs. three-phase connection. In most cases it will prove advantageous from the standpoint of the user of the equipment to use a single-phase transformer or if there is a bank of transformers to connect them in parallel, all on the one phase. Take, for example, a given welder and three single-phase transformers for stepping the voltage down from the incoming line voltage to the welder voltage. If these three transformers are connected in parallel on the one phase, there will be exactly one-half the voltage drop through the transformers as would be the case if the transformers were connected in a three-phase bank. Thus, it seems to me that where our problem is one of keeping the voltage drop at a minimum, we should certainly take advantage of the single-phase connection which cuts the transformer part of the drop exactly in half.

From the standpoint of disturbance on the system, the welder is still a single-phase load and no matter how the transformers are connected, whether single or three phase, the welder will cause approximately the same lamp flicker disturbance on the supply systems ahead of the transformers.

The usual reason for wanting to connect the transformers three phase from the utilities standpoint is that this will tend to balance the load of a group of welders on the three phases from a thermal standpoint. However, it takes such a large group of welders to provide any appreciable amount of load, thermally speaking, that by the time this becomes an appreciable factor the welders are located far enough apart in the plant so that it is not economical to serve them from any one location. Thus the group in one part of the plant can be served from a single-phase transformer on the first phase and groups in the other parts of the plant can be served from single-phase transformers on the second and third phases; thus retaining the advantage of the single-phase transformer connection and still balancing the load, thermally, on the three phases as far as the utility system is concerned.

## Low-Voltage Bus and Feeders

Starting with a total allowable drop of 10% and using up, say, 3% in the utilities' lines, local conditions will determine how the remaining 7% should be divided between the stepdown transformer bank and the low-voltage bus or feeder. In some cases it may be economical to put more money into the transformer bank, keeping that part of the drop at a minimum, while in other cases it may be more economical to concentrate on the low-voltage bus, keeping that part of the drop at a minimum. It's a simple matter of proper balance of over-all cost.

We have seen how it is possible to reduce the drop through the transformer bank with only a change in connections. Now, coming to the low-voltage bus or circuit, there are equal or even greater possibilities for reducing the voltage drop at relatively little expense. While adequate conductor size is essential, it is equally important that the conductors be installed as close together as practicable. To illustrate this, consider a bus consisting of two 1/4 by 4-in. coppers per phase with 14 in. between phase centers. By simply rearranging the same copper and interleaving the copper bars on 1 in. centers the voltage drop over the bus for low power factor welding current is reduced in the ratio of six to one. Where we could reduce the transformer drop in the ratio of two to one by proper connection, here an even greater reduction is obtained simply by rearrangement. The conductors should always be as close together as practicable.

## Good and Poor Installations

When it was first suggested that this talk be given it was requested that examples be cited of both good and poor welder supply installations encountered from time to time in plants around the system. Trying to think of some of the poor installations, again it has been necessary to go back several years as the more modern installations are in almost all cases well laid out with adequate transformers and low impedance feeders.

Some years ago in one of the large fabricating plants so much trouble was experienced in the welding department due to poor voltage conditions that the customer decided to completely re-design the power supply system. It was planned to pick up large groups of welders in their plant on separate single-phase buses, each fed from a stepdown transformer bank consisting of two 1000-kva. low impedance transformers in parallel. Each group of welders was connected to a different phase and the total welder load was balanced by connecting the separate single-phase transformer banks to different phases of the incoming supply. This looked like a good design until it was discovered that the low-voltage bus had widely spaced phase coppers. Fortunately this was caught before it was installed and the copper rearranged to form an interleaved bus; thus giving them a good installation all the way through.

In another case a plant having some 35,000 or 40,000 kva. of resistance welders was experiencing trouble in getting out production without an excessive number of rejects and asked that we increase the line capacity to the plant in order to improve the voltage at the machines. These particular welders were all fed over two 4800-volt underground lines from a "flicker bus" in a distribution substation about a mile distant. Before increasing the cable capacity to the plant we asked to make a study of the entire situation from source to load. It was found that conditions were bad, with voltage drops for the large machines in some cases as high as 40%. However, of this 40% drop there was found to be only 4% in the substation bus and 2% in the underground cables while there was 25% in the stepdown transformers, and about 10% in the secondary feeders. It was thus easily seen that an increase in the number of underground cables would make practically no improvement in the end results and that the best results for the least expenditure would be attained by changes in the stepdown transformer bank and low-voltage feeders. This is very often the case when it is found that there is an excessive voltage drop to a welder or a group of welders.

Figure 6 shows how *not* to do the job—whether it is a job of watering the lawn or a production job in welding. In the case of the welder, the supply transformer is too small, the machine is located too far from the transformer, the supply lines are too small and too widely spaced. The result is an expensive welding machine turning out more rejects than production. As compared with this, Fig. 7 shows good practice on any job. The same machine with an adequate supply, minimum distance and heavy low impedance wiring, gives high production with few rejects.

## Welding Machines and Their Operation

The design of the welding machine is important. The welding engineer is interested in obtaining a given

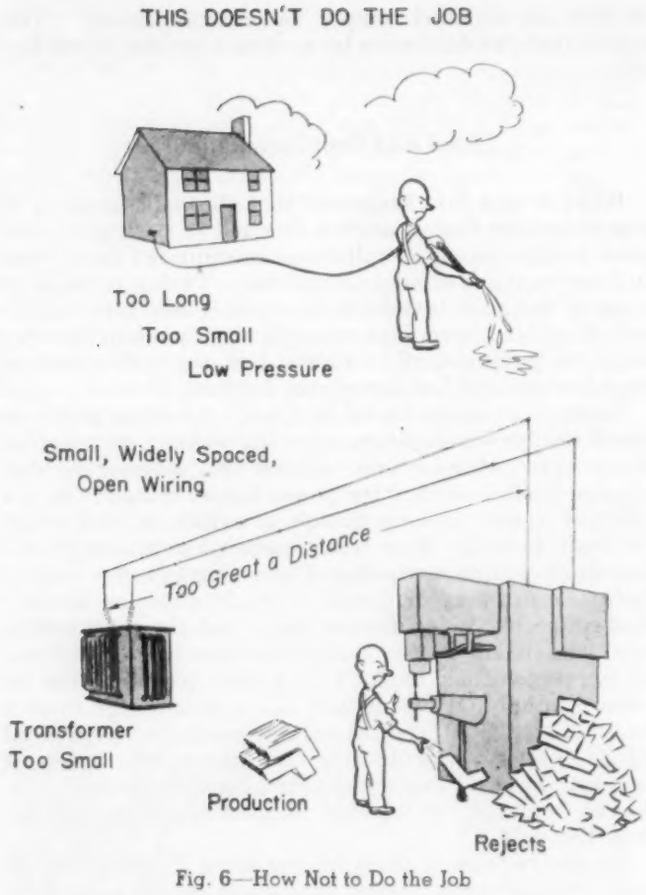


Fig. 6—How Not to Do the Job

amount of welding current in a specified time in order to produce a good weld. We might think that all conventional machines capable of delivering this amount of current would take equal amounts of current from the supply lines. This is not true. The amount of current drawn from the supply lines, while dependent upon the amount of welding current, is also dependent upon the design of the machine itself. The machine with a compact secondary circuit and a small throat will take much less line current when delivering the same welding current than another machine with a larger secondary circuit and oversize throat. So, while the welding engineer is interested in the amount of welding current the machine can deliver, the plant engineer is concerned with the amount of current drawn from the lines and in purchasing a new machine he is certainly interested in getting the machine that takes the least amount of current from the lines. The welder manufacturers have done a great deal in recent years in improving their standard designs and increasing their efficiency in terms of ratio of input-to-output current.

They have also done a good job in designing special machines with exceptionally low kva. demands. It is true that these special machines cost more money, but there are many locations especially in suburban areas where it is far more economical to put additional money into welding machines with low kva. demands than it would be to bolster up the power system to handle conventional machines. The cost can be figured both ways, and in many cases it will be found desirable to buy the special machines.

Among these special types of welders there is the stored energy welder, of both the magnetic and capacitance types, used primarily for welding aluminum but which can be used on light sections of ferrous metals. This welder presents practically no problem from the standpoint of power supply, although it does have the disadvantage of being limited to spot-welding operations only. The series capacitor welder, on the other hand, covers the broader field of spot, projection, seam and flash welding with much lower demand than that of the conventional machine. More recently there has been developed the three-phase welder that utilizes electronic conversion to produce low-frequency pulsations in the welding circuit. Another relatively new machine in the field is the storage battery welder which shows considerable promise.

All of these welders do a good job in reducing the amount of current drawn from the supply lines but they all cost more money than the conventional single-phase welder. We are often asked which of these machines is the easiest to serve. There is very little question but that the storage battery and the stored energy welders are in a class by themselves as far as their freedom from disturbing the power system is concerned. They would certainly be first choice from that standpoint. Somewhat farther down the line is the series capacitor welder, next the electronic conversion welder and finally the conventional single-phase machine.

The following simple analysis, summarized in Table 1,

**Table 1**

| | Conventional Single-phase A.-C. Welder | Three-phase Electronic Conversion Welder | Series Capacitor Single-Phase Welder |
|---|---|---|---|
| Line current | 5 | 1 | 2 |
| Line impedance | 1 | 1 | 1 |
| Voltage flicker: | | | |
| | | $1 \times 1 \times 1.73 = 1.73$ | |
| Reduce to noncyclic flicker | | $\times \frac{4}{7}$ | |
| | $5 \times 1 \times 2 = 10$ | | $2 \times 1 \times 2 = 4$ |

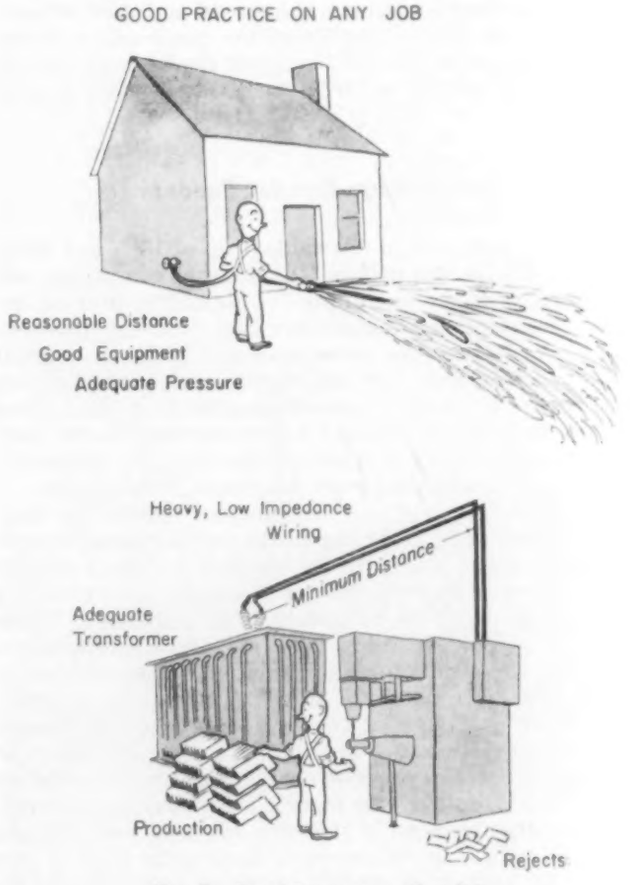


Fig. 7—Good Practice on Any Job

gives an admittedly rough comparison between the conventional single-phase welder, the three-phase electronic conversion welder and the single-phase series capacitor welder. Published literature on the three-phase electronic conversion welder states that the line current will be from $^1/_4$ to $^1/_6$ the line current of a conventional single-phase welder making the same weld. Calling this an average of $^1/_5$, five units of current can be indicated for the conventional machine as compared with one unit of current for the three-phase machine. Similarly, a series capacitor machine will draw about 40% as much current as the conventional single-phase welder when making the same weld. So in this case only two units of current are required.

Assuming the same line impedance in all cases, there are 10 units of flicker for the conventional single-phase welder, 1.73 units for the three-phase welder and 4 units for the series capacitor welder. However, the three-phase welder is pulsating and consequently the permissible flicker limit is only one-fourth as much as that for the other two machines which are of the single impulse type. It is therefore necessary to multiply 1.73 by 4 to get all three machines on the same basis from the standpoint of lamp flicker. Thus it is found that the three-phase welder will cause about 70% as much effective flicker and the series capacitor welder will cause about 40% as much effective flicker as the conventional single-phase welder when served from the same supply facilities and making the same weld. It should be emphasized that this is a very general comparison, neglecting such important factors as power factor of the load, the ratio of resistance to reactance of the supply system, and changes in wave form, all of which have an important bearing on the results achieved in a specific case.

In conclusion I would like to express appreciation to the users of welding equipment in this area as well as to the manufacturers of that equipment. In practically all cases we have had 100% cooperation from both of these groups. In seeking improvement in the ways and means of serving a load which admittedly hasn't been too easy to handle, the manufacturers have done an excellent job in improving their designs, both on the standard machines and in the design of special low imput machines and, what I think is perhaps more important, they are now able to tell us in advance what a specific welder demand is going to be. This permits the user, the manufacturer and the utility representatives to sit down around a table and mutually arrive at the most economical and satisfactory way of serving a given welder at a specified location.

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(*Continued on page 837*)

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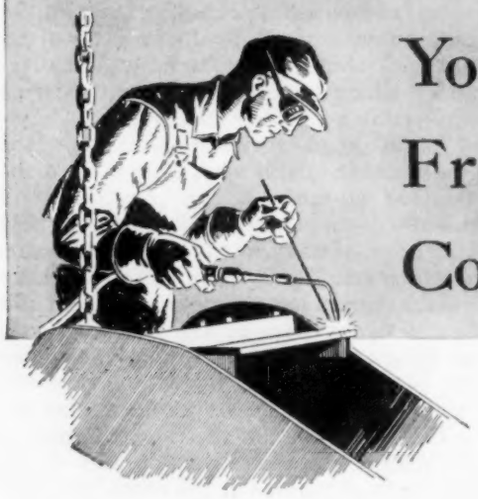

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# A Machine for Production Flame Cutting of Small Shapes

By E. E. Hart*

THERE has recently been installed in the Ordnance Division of the John Inglis Co., Ltd., Toronto, Ontario, an eight-torch flame-cutting machine in which all operations, after the multi-component bars are placed on the machine, are mechanically carried out. That is, the locating, cutting, ejection of cut components, and positioning of the bars for the next cut, and the conveying of the cut components to a point where they may be shoveled into skids for transporting to the next operation, are mechanically carried out. Figure *A* is a photograph of the original model made up to prove the drawings prior to manufacture of the machine. Figures 1, 2 and 3 give general views of the machine, and Fig. 4 a drawing of the four components cut on the machine to the same scale, and the savings produced on the basis noted for each in 4*A*.

This discussion will be limited to shapes of up to 3 × 7 × 24 in. or thus, small shapes.

There are two types of material which may be used for flame cutting: (*A*) Plate; (*B*) Bar Stock of such size that the edges are used as one face of the component. The cost per pound is approximately the same.

The advantage of *Plate* is as follows:

1. Expensive locating means are not required, or in the alternative, the expenditure of much time to locate a bar for each cut. This is due to the fact that ordinarily in plate the component is cut all the way around the shape, by the flame, and thus the accurate location of the edge in relation to the torch and the template is not important.

The advantage of *Bar Stock* is as follows:

1. It is often possible to leave one edge of the bar as an edge of the component, at a saving of from 0.13–0.75¢ per inch of cut, and also produce a superior spotting face for the first machining operation.

* Material Standards, John Inglis Co., Ltd., Ordnance Division.

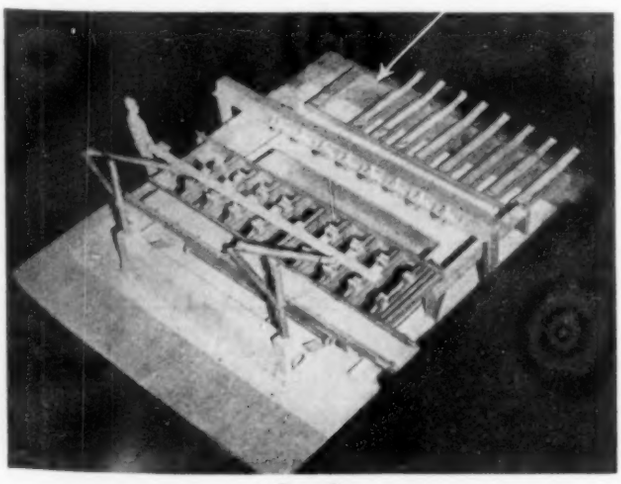

Fig. *A*

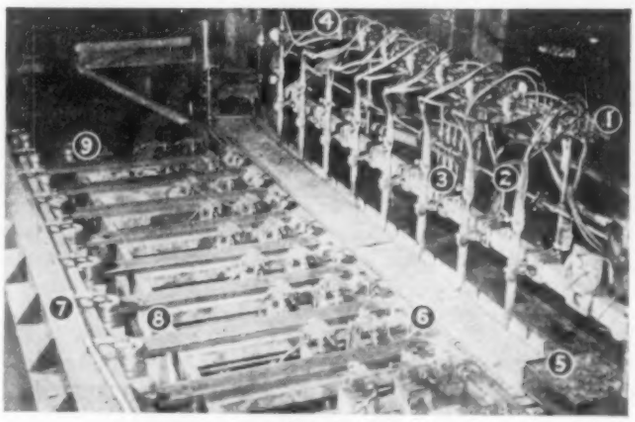


Fig. 1

2. A large saving in weight of raw stock required for the production of a given shape is almost always possible in the case of a correctly chosen bar, as against plate. This is extremely important in the case of gun steels which may contain up to 3½% of nickel, and may cost up to 10¢ per pound. The cost of the steel will usually greatly outweigh the cost of the cutting.

3. Greater accuracy is often possible, as for many dimensions only one flame-cut edge is involved, instead of two in the case of plate.

4. Many shops are not equipped to handle large and heavy plates.

Where up to two or three hundred components are involved it is usual, providing facilities are available, to choose plate. Where a few thousand are involved, bar stock is used, with some simple means of hand locating the stock. Where very large quantities are involved it would appear that bar stock would usually be chosen, and some more elaborate means of handling the stock developed. The following is an effort to accomplish this latter objective for small components.

One of the obviously wasteful features of the standard single-torch flame cutter is that only one piece is being cut at one time. In order to overcome this difficulty the use of an eight-torch pantograph frame flame-cutting unit was suggested. This unit, a standard piece of equipment, possesses a torch holding bar 12 ft. long which permits spacing the torches at 15-in. centers. It is equipped with a pipe type gas manifold as illustrated in Fig. 1, item *1*. Approximately equal length rubber hose leads would thus extend to each torch with equal line drop to each torch and thus similar gas conditions at each cutting tip. The pantograph assembly was such that a useful movement at right angles to the torch bar of approximately 60 in. with at the same time a parallel movement of 7 in. was obtained. Thus a bar 7 x 60 in. could be cut under each of the torches. While no definite decision could be reached it was felt by all concerned that

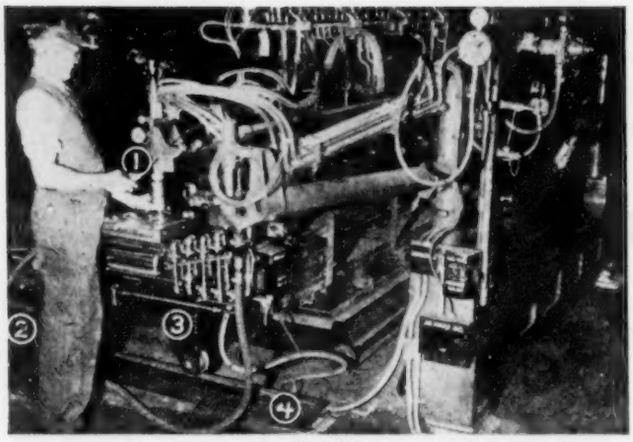


Fig. 2

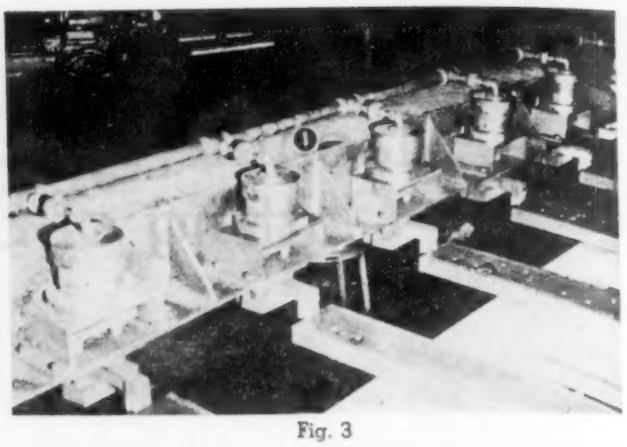


Fig. 3

eight torches represented a reasonable compromise between the conflicting factors of maximum number of simultaneous cuts and increasing loss per torch due to the need of cleaning any one of the torches. That is, there are eight factors to tie up the machine instead of one. The *torch holding bar* is moved during operation by a magnetic motor-operated variable speed tracer, item *9*, Fig. 6.

The *gas supply* to the torches is controlled by bar *2*, Fig. 1. Cams fixed on this bar open in turn, as the bar is rotated, spring-loaded valves at *3*, Fig. 1, which supply first an extra blast of illuminating gas to the pilot lights, then preheat oxygen and acetylene and then the cutting oxygen. In order to provide individual control of the cutting oxygen to each of the torches, electromagnetic valves, item *4*, Fig. 1, were installed in each of the cutting oxygen torch leads. These may be controlled in a group by switch *1*, Fig. 2, which also controls the tracer motor, and thus allows the cutting oxygen and the tracer motor to be started simultaneously from one switch, or individually by the eight torches, item *5*, Fig. 1, thus allowing any or all of the torches to be operated at one time. This latter device is handy if one of the torches fails to start cutting at the right time. *Oxygen* for the operation is obtained from a distribution system in the plant. Gas is fed into this system from carriers holding approximately 32 cylinders. Acetylene is also obtained from a plant distribution system, which system obtains its supply from generators utilizing calcium carbide. Oxygen is sup-

| Item | Actual Production/hr 1 operator & 1 helper | Oxygen/component c.f. | Acetylene/component c.f. | Gas Cost/component $ | Labor cost/component including overhead $ | Cost of Drilling Starting Holes $ | Cost of Component not incl. Material $ | Cost of Extra Material for Flame Cutting over Forging - $ | Flame Cutting Cost on same basis as Foring $ | Cost of Forging not incl.Material - $ | Saving by Flame-Cutting $/Component | Production to date by this method on 8-torch machine | Gross saving to Oct/44 by using 8-torch Machine - $ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $ | $ | $ | $ | $ | $ | | $ | | $(approx |
| 1 | 50 | 14.62 | 1.28 | .1500 | .0814 | | .2314 | Cr.241 | Cr.0096 | 2.45 | 2.4596 | 26,000 | 70,000 |
| 2 | 80 | 4.86 | .72 | .0548 | .0481 | .0482 | .1511 | .0354 | .1865 | .53 | .3435 | 10,000 | 39,000 |
| | x | | | | | | | | | (est. | | ■ | |
| 3 | 360 | .80 | .167 | .0099 | .0105 | | .0204 | | .0204 | .10 | .0796 | 3,600 | |
| | est | | | | | | | | | (est | | ■ | |
| 4 | 250 | 1.30 | .212 | .0154 | .0156 | | .0310 | | .0310 | .20 | .1690 | ,200 | |

Gross Saving .. $109.000

x This is a 2 piece component. Production of 2 pce blanks - 180/hr.

■ These two operations were cancelled before substantial production was started.

It is estimated that the cost of cutting on a single torch machine equipped with locating means would cost three times the amount on the 8-torch machine, and that four machines at least would be required. The saving by cutting the above production on the 8-torch machine, is thus $34,000.00.

Fig. 4*A*

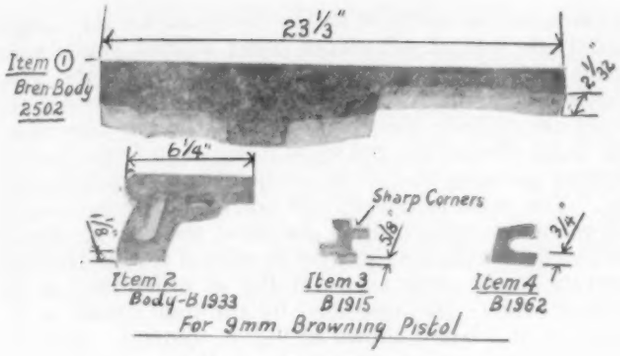


Fig. 4

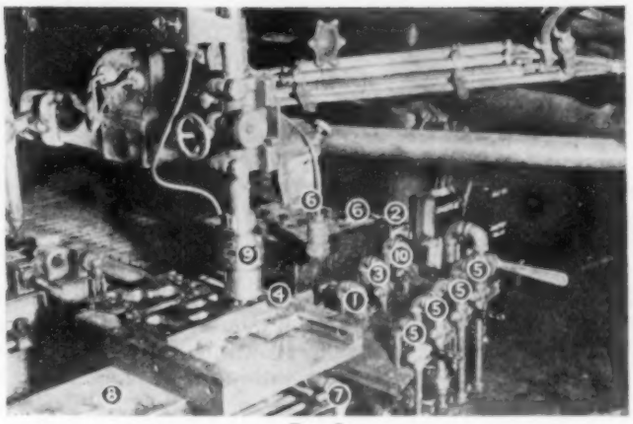

Fig. 6

plied at 120–140 psi., and acetylene at 13 psi. This machine was purchased as offered.

The other major and obvious loss factors in many flame-cutting units are:

(*a*) For bar stock: Lost time in manually or semi-manually locating the stock.

(*b*) For both bar stock and plate: Lost time in clearing the machine of cut components and, in some cases, also of scrap.

"A"

To overcome (*a*) it was decided to carry the stock on a trolley, item *3*, Fig. 2, which trolley was mounted on rails, item *4*, Fig. 2, at 12-ft. centers set at right angles to the torch bar. The trolley carries a light frame, item *8*, Fig. 1, bolted to it, which constitutes the cutting channels themselves, with the template at one end of this frame, item *8*, Fig. 6. The stock is placed on the trolley from the front with the trolley as far forward as it may be moved. This is the last time the stock is touched manually. Forward ram-operated slides, item *1*, Fig. 5, or item *6*, Fig. 1, are then pushed out by operating air valve, *10*, Fig. 6, on the main control board. For locating the trolley with all cutting positions in a line parallel to the line of the torch bar, two heavy fixed frames are provided, item *2*, Fig. 2, and item *1*, Fig. 7, being the frame on the operator's side of the trolley. On each of these frames are located accurately drilled plates, item *2*, Fig. 7. Two large air rams, item *3*, Fig. 7, are located on the trolley to drive pins into the drilled holes and fix the trolley position. At the back of the trolley is located a fixed frame, item *7*, Fig. 1, or item *1*, Fig. 3, carrying pusher bars. These pusher bars are equipped with air rams to free them in their longitudinal direction, and are also equipped with springs in the longitudinal direction, which when depressed will exert substantial pressure in that direction. With the stock on the trolley and the forward locators extended as above described, the rear locators are freed by operating their air rams through valve *1*, Fig. 6. The trolley is run back until the trolley locating pins contact the first drilled holes in the side plates. In the process of moving the trolley back the stock is pushed against the freed rear locators which are partly depressed, and develop through their longitudinal springs, pressure to drive the stock forward against the forward locator slides. The front ends of the bars are thus in line with the torch bar, the rear locators taking up the bar length tolerance. The rear locators are then locked by releasing the vertical air rams, springs being provided inside the rams for this purpose. The forward slides are then withdrawn by the spring in the forward rams (occasionally a tap by the helper is also required). The trolley is operated by a motor operating through a reducer and driving a shaft carrying at either end a pinion which operates in chains, which are in turn held on the fixed side-locator frames. This may be open to criticism as representing a fixed drive from two points, but it has the very necessary effect of assuring practically simultaneous location of the two trolley locating pins. The drive is shown in Fig. 7. When the trolley pin on the operator's side is raised it contacts the limit switch, item *4*, Fig. 7, which starts the trolley motor, driving the trolley in either direction—controlled by switch *2*, Fig. 6. The motor will continue to operate until the locator pin is depressed and the limit switch released. This will happen when the locator pin controlling the limit switch drops into a hole. Thus, to operate the trolley, valve *3*, Fig. 6, is closed, and heavy springs in the trolley locator rams raise the pins, thus starting the motor through the limit switch. When the trolley has passed the holes in

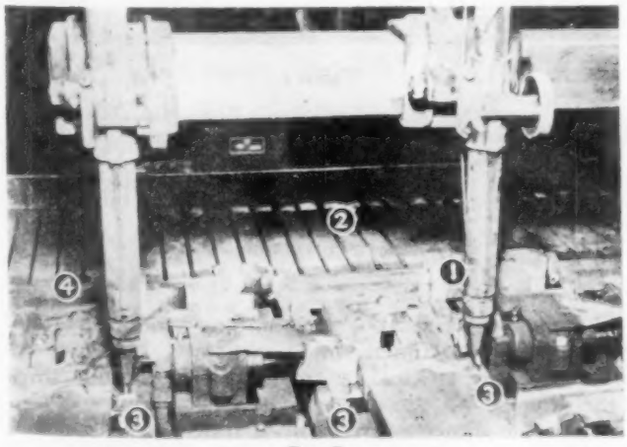

Fig. 5

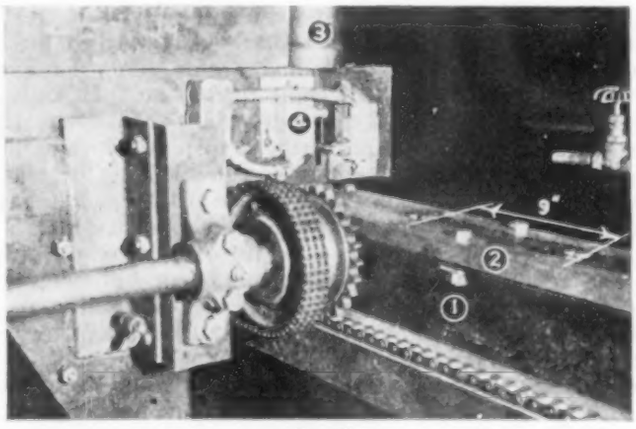

Fig. 7

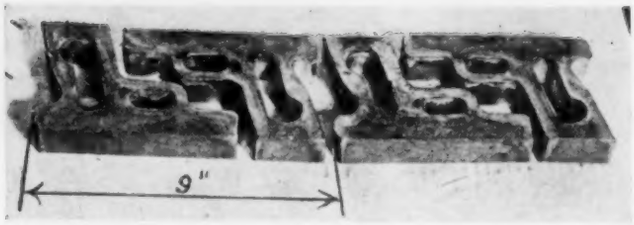


Fig. 8

the side plates the valve is again opened, but the plates prevent the pins from dropping enough to release the limit switch, and the trolley continues until the pins drop into the next holes, thus automatically locating the trolley. When a group of components have been cut, the trolley is moved back in the manner just described, by an amount equal to the length of the bar just cut—for instance, the 9-in. length in Fig. 7 and in Fig. 8. The moving back of the trolley, due to the fact that the rear locators are now fixed, results in pushing all the bars forward an amount equal to the amount that the trolley is moved back, thus ejecting the cut components onto the pallet conveyor, item *2*, Fig. 5, and bringing the stock automatically into position for the cutting of another similar group of components. The cut components are transported to the side of the machine by the conveyor, from which they are shoveled into a skid by the helper and trucked away. Question might be raised as to why it was decided to move the cutting frame instead of the unit supporting the rear locators. This was done because:

1. The cutting frame being heavier by nature than the rear frame, and also larger, it was more easily controlled on the tracks. It is of paramount importance that the moving unit move in a direction parallel to a close accuracy with the torch bar.
2. The facilities for handling and storing stock in the plant did not lend themselves to the use of bars longer than 60 in. due to weight. Thus, while moving the rear locators would have permitted the use of longer bars, this was not possible in this plant in any case. The writer questions whether the use of longer and heavier bars than could be handled by one man would ever be justified.

*"B"*

The main item in Loss Factor (*b*) is the location of the side faces of the stock, which problem was handled as follows. A center line was placed on each cutting channel and the various side locating blocks, items *3*, Fig. 5, laid out from this line. A hole, item *4*, Fig. 5, capable of holding the end of the torch tip was then drilled on each of the center lines at a definite position with regard to the stops. Another hole, item *4*, Fig. 6, was drilled to take the tracer pin in the template, which bore the same relationship to the template as the previously drilled torch holes did to the cutting channel stops. It is therefore possible, by lining up the eight torches and the tracer simultaneously in their respective holes, to assure, if stock be held tightly against the correct stops, that the eight torches will cut eight pieces identical to the template being used, within the tolerance of the machine (as hereinafter). On three of the four components cut, the fairly wide rolling tolerance in width of the bar is eliminated in all dimensions of the component but one, by spotting from one face and cutting one component and then moving the bar over and spotting from the opposite face, for cutting the meshing component—this being done on a second template plate related to the second set of spotting blocks—see Figs. 5 and 6. Where inside holes are cut (as well as an outside cut) a second hole-template is provided, in addition to the template for the outside cut, both sets of templates being related similarly to their respective stops. In drilling the bar for the holes, the bar is similarly moved from side to side when the holes are drilled; thus regardless of the bar dimensions the holes always are the same distance in from the controlling spotting face of the component to which they refer. The stock is moved from side to side by two rows of air rams operating in each direction, see Fig. 1. It will be noted that these rams may be moved so that they will operate at any point on the trolley at which they are required. They are controlled by the four valves on the main control board shown in Fig. 6, items *5*. Air-operated switches are provided in the trolley motor circuit to prevent the trolley moving if any of the stock rams are operating, and in the tracer motor circuit to prevent the tracer operating if none of the rams are operating when the stock would not be against the stops. Green signal lights are installed, item *6*, Fig. 6, operated by limit switches, which light when the trolley locator rams, item *3*, Fig. 7, and item *9*, Fig. 1, are fully in the locating holes, and thus it is safe for the operator to proceed with the cut. Operating in conjunction with the pressure cutout switches on the tracer motor previously mentioned, are two green indicator lights mounted on the template, which indicate which template plate should be used, that is, against which set of spotting blocks the stock is being pushed. These are not shown in the photographs.

Scrap is disposed of through openings cut in the cutting channels, and falls into a slag car below, which is partially filled with water and thus quenches the slag and scrap metal. This is shown in Figs. 2 and 5. A light spray is provided, item *7*, Fig. 6, being the one end of the spray pipe, which effectively cools the trolley. A drain-off valve is used in the bottom of the slag car to drain off surplus water into an open drain around the car, which drain also catches any surplus water from the spray. These two means serve greatly to reduce the very excessive heat often noted around flame-cutting machines and which largely originates in the hot slag and scrap.

## Cutting Tolerances

Table 1 gives the tolerances which have been found to exist in the cutting which has been done to date on this machine. These tolerances are, of course, those which exist with fair to good operators, and torches have been adjusted to bring the tips into the torch location holes accurately. They, of course, do not apply if the torches are bumped so as to throw out this adjustment and are not readjusted. The operators must be instructed to check their torches whenever a severe bump occurs. They should also be supplied with high and low gages for the piece to be cut.

**Table 1**

| Stock Thickness, In. | Cut $O_2$ Hole Diam. in Tip | Variation in Position of Flame-cut Edge from Nominal Position | Max. Depth of Surface Corrugations |
|---|---|---|---|
| 0.625 | 0.029 | Plus or minus 0.010 | 0.010 |
| 0.750 | 0.036 | Plus or minus 0.015 | 0.015 |
| 1 | 0.052 | Plus or minus 0.020 | 0.030 |
| 2 | 0.070 | Plus or minus 0.030 | 0.045 |

These are the tolerances for one line produced by the torch. Where a dimension is measured between two flame-cut edges, twice these tolerances are the tolerances of the dimension.

Where the dimension is from a rolled to a flame-cut edge, the above tolerances apply to the dimensions.

## Width of Cut and Flames Used

Following are the widths of cuts which have been found to exist in the four pieces cut on the machine, and the tips and their orifice dimensions. In all cases it has been found advisable to cut down the preheat flames to the minimum that the cutting flames used will permit. It will also be noted that the pressures used are somewhat in excess of those normally recommended. It has been found that the greater pressures tended to blow the slag clear of the work, with the result that it is now not necessary to clean the components after cutting.

**Table 2**

| Part No. | Stock Thickness, In. | Cut $O_2$ Hole Diam., In. | Cut Pres., Lb. | Speed Cut, In. | Width of Cut, In. | Preheat Time, Min. |
|---|---|---|---|---|---|---|
| B-1915 | 0.625 | 0.029 | 40 | 12.5 | 0.063 | 0.20 |
| B-1962 | 0.750 | 0.036 | 40 | 12 | 0.090 | 0.25 |
| B-1933 | 1.125 | 0.052 | 62 | 12 | 0.125 | 0.25 |
| 2502 | 2.032 | 0.070 | 70 | 7 | 0.234 | 0.33 |

## Material for Use on Machine

Where material is to be used for flame cutting, it has been found that the following precautions are desirable.

1. It should have good surface conditions, i.e., it should be free from undesirable surface pitting, rounded corners, crowning, etc. This is specified so that the material will not be so poor in quality, dimensionally, as to require such a stock removal to clean up, that the good cutting tolerances are rendered of no value.

2. It should be pickled so as to remove all scale prior to cutting. This may be done at the supplier's plant or on the premises. Moderate rusting does not seem to unduly interfere with cutting, but scale cracking off from the surface and entering and plugging the tips causes much waste of time. The small cost of pickling is amply justified by the results obtained.

3. If the stock is over 0.40% carbon, it should be ordered with a provision that total decarburization should not exceed 0.006 in. per side. This specification was introduced following the developing of the cutting technique for B-1915, Fig. 4, item *4*, in which it was found that decarburization in excess of the above amount caused an intolerable slag adherence to that S.A.E. 1075 steel. The writer feels that this discovery, which was made by the Metallurgy Department of this company, is exceedingly important and is fully discussed in an article by Mr. J. K. Magor of that department appearing in the February 1945 issue of *Canadian Metals & Metallurgical Industries* magazine.

## Minimum Corner Radius

The minimum radius which may be cut is dependent upon two factors:

1. The radius of an internal change of direction must be:
   - (*a*) For $^5/_{16}$-in. Diam. Tracer—$^5/_{32}$ in. + $^1/_{16}$ in., or $^7/_{32}$ in. min.
   - (*b*) For $^1/_2$-in. Diam. Tracer—$^1/_4$ in. + $^1/_8$ in., or $^3/_8$ in. min.

in order that the magnetic roller will not lock in this radius and slip.

2. As the thickness of the metal being cut, increases, the concentration of flame and slag in one area, due to heavier flame, tends to increase for any given corner radius, resulting in "blows" being produced if this radius is too small.

Experimental work, and experience in this plant, has been very limited to date, but we have, however, found so far that:

- (*a*) The minimum condition in 1 (*a*), above, controls for B-1915 and B-1962 ($^5/_8$ in. and $^3/_4$ in. thick) which are cut with $^5/_{16}$-in. diameter tracers.
- (*b*) The minimum condition in 1 (*b*) controls for B-1933 ($1^1/_8$ in. thick) cut with $^1/_2$-in. diameter tracer.
- (*c*) The minimum radius for 2502 (2.032 in. thick) has turned out to be $^3/_4$ in., however, instead of $^3/_8$ in. as would apply to the $^1/_2$-in. tracer used. This was due to troublesome "blows" being created by the $^3/_8$-in. diameter radius.

## The Economic Position of This Type of Machine

The cost of the machine as described herein was approximately $14,000 plus initial adjustment and experimental costs of possibly $6000 over a three-month period. These would probably be much lower in any subsequent machine.

It will be noted from Fig. 4 that the savings in the first six months of operation of this machine (only three months of which were at full production, due to the project for which three of the parts were destined, being in the tool-proving stage only, during the first three months) amounted to $109,000 as compared with the cost of the forgings, which in the case of the two bodies they replaced and in the case of the two other pieces, would have been the alternative design. It will also be noted that the saving over the use of a single torch unit (utilizing an estimate only) for the Bren Body amounted to $34,000—not including the possible three machines which would have been required for the production in question, and which would have cost around $7000. Production has been found to run at approximately 55 to 60% of the theoretical figure which would be derived by totaling cutting time, preheat time, template tracer moving time, and stock ejection and loading time. About 25% of the 40 to 45% of lost time may be ascribed to tip cleaning, and the rest to operator inefficiency. This figure is similar to many machining operations at the present time.

It would appear, therefore, that where the shape is small and flat, or sufficiently close to flat that little or no extra machining would be required if it were flat, and where material flow lines are not a critical consideration, and where the production is sufficiently large to readily absorb the tooling expense of about $400 per component cut, and the capital cost of the machine, flame cutting, utilizing a machine of design similar to the one herein described, should be considered. If the quantity is small, a less expensive flame cutter and setup should be used, utilizing bar stock or plate as the shape and quantity warrants.

In closing, the writer would like to acknowledge the cooperation which he has received in this development, from Mr. R. S. Dunn of the Canadian Liquid Air Co., Ltd.

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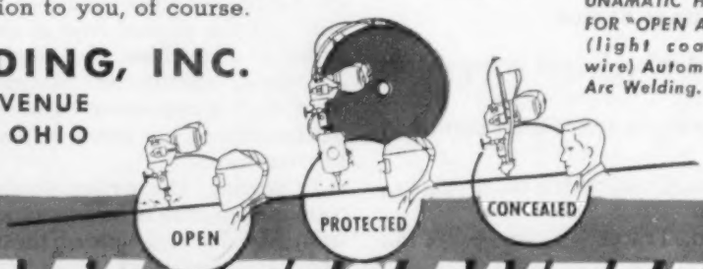


# UNAMATIC WELDING

# Arc-Welding Engineering Problems and Engineers*

By Walter J. Brooking†

WITH the increase in the use of the arc-welding process for the manufacture of machinery and equipment during the past few years and especially augmented by the production of large amounts of equipment for military purposes by arc welding, the problem of training capable specialists for welding control and processing has become of increasing interest to the industry.

The fundamental idea of welding engineering is that by scientific, objective study and evaluation of the elements of a situation, a choice may be made or a method may be developed which can be demonstrated to be sufficiently better than other possible choices or processes so that it presents an economic margin either in cost or quality of product.

Many of the problems encountered in a manufacturing organization which produces the heavy earthmoving equipment unit shown in Fig. 1 on a mass production basis are somewhat different perhaps from the manufacturer of airplane fuselages, or the manufacturer of ships; and the problem of any of these mass production shops is naturally different from the organization who operates as a large job shop producing special machinery built to special order.

However, large mass production producers of welded equipment encounter many of the same problems as does the specialized job shop if they build special shop machinery or fixtures such as the special sheave pin drilling machine shown in Fig. 2. The designing, engineering and manufacture of these special shop units bring about problems which are in many respects the same problems that are faced by the large job shop.

* Presented before Milwaukee Section, A.W.S. A more complete coverage of the problems given in this paper can be found in a recent book by the author published by McGraw-Hill Book Co. entitled *Arc Welding Engineering and Production Control*.

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**Fig. 1—Examples of Modern Mass Production of Arc-Welded Equipment**

These wheel type tractors and earthmoving scrapers are produced in lots of 100 or more per order by specialized workmen on modern manufacturing and assembly lines.

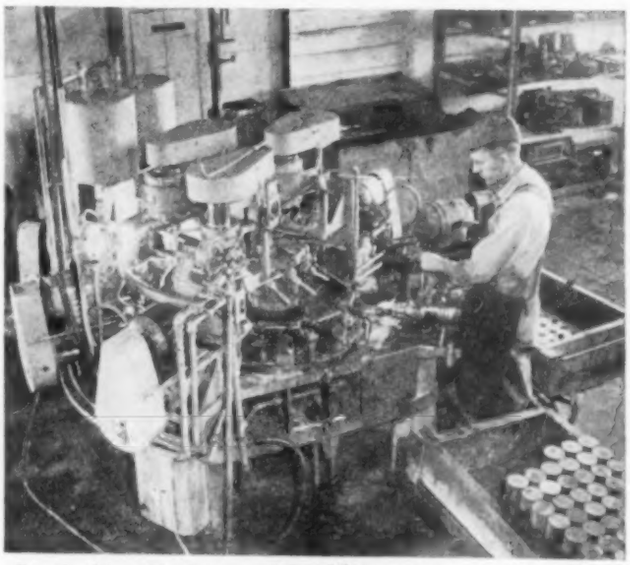


**Fig. 2—Mass Producers of Arc-Welded Products Have Many Typical "Job Shop" Jobs If They Build Their Own Special Equipment. This Unit Was Designed to Drill Sheave Pins Semiautomatically**

In considering the work of the welding engineer one thing must be kept in mind above all others, namely, that all of the various fields of operation which might be considered to be welding engineering added together form a series of activities and a group of problems and details which are beyond the scope of one individual man in anything but the very smallest of organizations. However, these various fields in some organizations may be somewhat centered around one man or a very small group of men; and in some others quite widely shared by many people in the organization. A general analysis of the operations and functions which must be performed in the production of welded equipment either on a mass production scale, or on the job shop operation scale will tend to illustrate the welding engineering functions which someone in the organization should know and should be able to perform.

It should be borne in mind continually that the fields of operation are described not as the work which one man should do; but rather as a description of the functions which have to be done.

With this in mind the following list of general operations and problems of organization which must be dealt with occur in arc-welded production.

1. Evaluate and select welding processes, machines and equipment.
2. Evaluate and select appropriate welding electrodes for all processing done in the plant.
3. Examine and evaluate welding operators seeking employment.

4. Train and adapt welders to the company's special processes.
5. Correlate welding design with practical shop practice and available shop equipment.
6. Create production fixtures for welding (setting up and positioning for welding).
7. Establish the general procedures for welding the company's products.
8. Establish production control of procedures in detail.
9. Establish quality control (inspection).
10. Keep abreast of practices and processes in the industry so as to keep the company's processing up to date.

In looking over and thinking about these ten fields of activity it is obvious that they are beyond the ability of any one man in any manufacturing organization of any size; but an analysis of personnel available compared to the functions involved indicate related functions, where special talents on the part of personnel will allow them to assume certain of these responsibilities.

The selection of any portion of this group and establishing it as the special work of one person called a welding engineer and applying that particular selection of duties to the profession of welding engineer for all or ganizations would be a completely impossible plan. However, the function served by a welding engineer in an organization will certainly include some of the ten general fields, and perhaps a portion of all of them integrated with other departments and personalities in the organization.

With this in mind as the broad welding engineer's job it may be assumed that some welding engineers might perform certain of these functions and that other engineers will perform the remainder. An analysis of the duties involved in each of the ten groups will now be undertaken.

## Evaluating and Selecting Welding Processes, Machines and Equipment

The fundamental decision having been made by an organization to manufacture by the arc-welded method there are still problems to be solved as to what type of welding machine and equipment should be used.

The question as to whether a.-c. of d.-c. machines should be purchased for the company's product is one which is strictly a welding engineering problem. Someone in the organization must know or find out, based on a study of material, power, type of welded product, etc., whether the use of alternating current from a transformer type welding machine such as is used by the welder in Fig. 3 for the mass production of a part of a heavy earth-moving machine; or whether a motor-generator type d.-c. welding machine is more practical for that particular organization.

Fig. 3—The Selection of the Best Type of Welding Equipment for This Type of Mass Production Job Is a Problem in Welding Engineering

A study of the question as to whether parts of the manufacturing process might better be done by automatic welding or manual welding also is a welding engineering problem.

After the decision as to the type of machine to be used has been made, the problem of selecting from the available sources the particular machine which shall be used in the plant or the best machine to replace such machines such as are already in the plant when they become obsolete is another problem of welding engineering.

The determination of the size (or capacity) of the machine is also a decision which should be made, considering the type of work which is going to be done, the variety of work which the machine will have to do with special attention to variety of size and type of electrodes and relative continuity of use (50 min. per hour for 24 hr. a day and 30 min. per hour for shorter hours per day).

In order comparatively to test and evaluate machines within a group of fundamental types (a.-c. transformer or d.-c. motor generator) or (automatic welding) the man who does this work need not necessarily be a full-fledged electrical engineer although certain considerations of power consumption, fundamental efficiency and equipment investment require an analysis which is of a rather technical nature.

The actual comparison of machines within a group, the process of comparatively testing them on the basis of operation, operating characteristics, over-all efficiency, and probably satisfactory service may best be accomplished by objective comparative tests, plus examinations of the machines from the mechanical standpoint.

Such tests should always include actual deposition tests in which a certain number of electrodes or quantity of welding is done under controlled conditions. Whenever possible they should also include careful over-all consumption studies using a recording kilowatt meter or some other means of determining the amount of power used, and the amount of time (labor) required to do a certain job of deposition of metal.

Such tests should also include a study of the extremes in setting and operating of the machines such as the lowest amperage possible to obtain and therefore the smallest electrode usable as well as the characteristics of the reaction of the machine at very low settings or very high settings.

Another thing which the recording kilowatt meter may be used to describe is the speed with which a welding machine may be brought to its welding efficiency after the arc has been struck, compared to another machine. Figure 4 shows such a recording of the arc-striking characteristics of three separate machines and demonstrates a very noticeable difference between them.

Other equipment besides welding machines also must be selected and evaluated such as hoods, cover glasses electrode holders, cables cleaning brushes and slagging tools.

Methods of grounding welding machines, and installation of the ground and arrangement of machines in the factory proper for efficient welding are also related problems requiring study. These problems are all problems which offer a variety of solutions, and if someone in the organization (whether he is called the welding engineer or something else) can conduct objective tests upon the problem and arrive at an answer which can be demonstrated to be the best of several, it constitutes the engineering approach to the problem.

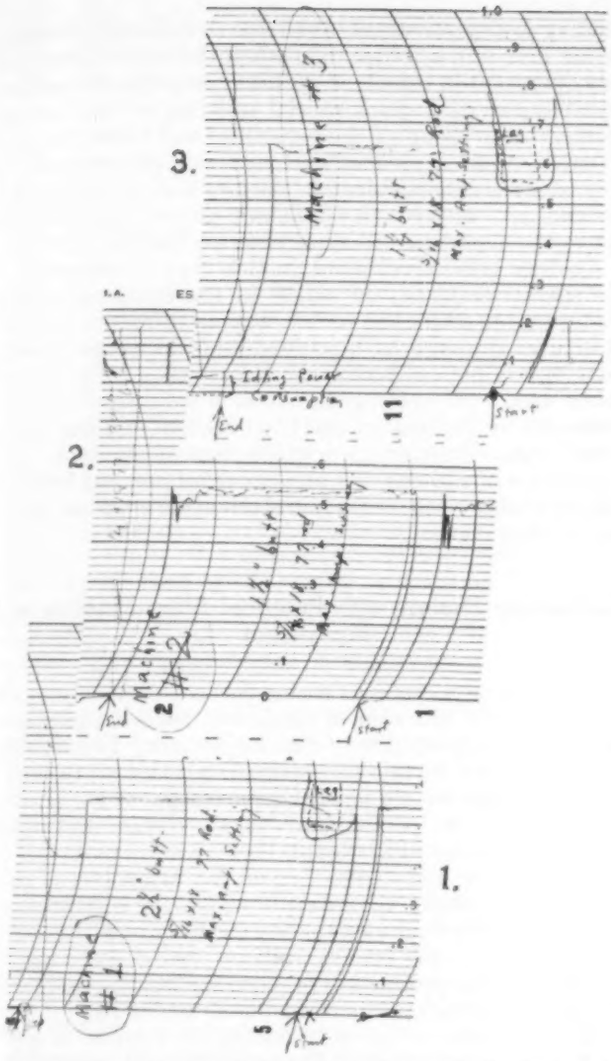



Fig. 4—Automatic Recording Equipment for Testing Welding Machines or Electrodes Provide the Welding Engineer with Valuable Data

Note the difference between Machine No. 2 and Machine No. 1 and No. 3 as shown by the recording kilowatt meter, showing that Machine No. 2 rises immediately to full welding current delivery after striking the arc, while No. 1 and No. 3 lag in output for several seconds.

## Evaluating and Selecting Welding Electrodes

Since welding electrodes are a fundamental raw material of the arc-welding process and since the weld metal deposited in the welding process becomes an integral part of the product, careful study and evaluation of welding electrodes presents a very important field for objective and detailed study.

A complete discussion of this subject in this review of welding engineering factors is impossible but there are certain major considerations about electrode selections which are of considerable importance on any job.

One of these is that the electrodes must be selected for the type of material being welded upon and must operate to the best advantage with the welding equipment and the skill of the welding operators which is current in the organization.

For ordinary steel welding operations on a mass production basis, there are sometimes special physical requirements which must be met by the electrodes and the welding process. These may be tested by control agencies outside of the organization, but someone in the organization must understand the fundamentals of the selection and testing of the welding electrode as a part of the use of the welding process for production.

Another major consideration in welding electrode selection is that of using the electrode best adapted to the common positions in which welding is done in the plant, for example, down-hand welding using A.W.S. class E-6020 type electrode (for ordinary low-carbon steel) and E-6010 or E-6012 electrodes for horizontal, vertical or overhead in order to most economically deposit the weld metal.

The consideration of special types of electrodes such as special hard-surfacing or high-tensile electrodes to accomplish special needs in the manufacture of the equipment or maintenance of regular manufacturing machinery is another important series of studies which should be made by the organization in the interest of getting all possible economy from the arc-welding process.

Comparative tests of electrode within a certain type such as comparing the E-6010 electrode produced by various companies as applied to the special welding problems of the organization constitute another effective source of economy if approached from the engineering standpoint —that of controlled, scientific measurements and tests.

This phase of the welding engineering in an organization is not one which can be done once and forgotten about, but is one which requires periodic re-examination and testing in order that the organization may be assured that it is at all times following the best practice and using the electrodes best adapted to their particular type of production.

These tests always have two phases. The first phase is that of operating characteristics from the standpoint of ease of handling, speed of deposition and ease of slagging as seen from the welder's viewpoint.

The second phase is that of economic advantage which involves the original price of the electrode, the percentage deposited, the actual cost of the finished unit of welding as effected by the electrode. Whether this testing is done by a Testing and Research Department, a "welding engineer" or by a production foreman, the same fundamentals of careful scientific study must be followed in order to best evaluate the electrode and assure the organization that the best work is being done in that respect.

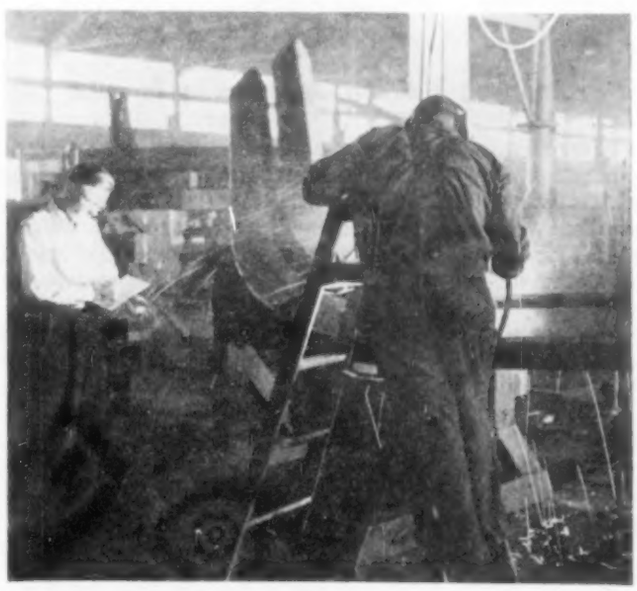


Fig. 5—Regularly Run and Carefully Controlled (Stopwatch, Rule, Ammeter and Weighing Balance) Electrode Comparison Tests Are a Source of Economic Margins for Manufacturers of Arc-Welded Products

Fig. 6—The Training of New Welding Operators or Adapting Skills of Previously Trained Welders Is Another Important Function of a Modern Welding Organization

## Evaluating and Testing Welding Operators

Welding operator testing and qualifications is another phase of the work in a welding manufacturing plant. As the method has become more widely used throughout the country, there have been a larger number of welding operators trained in various types of arc-welding manufacturing jobs. With the changing personnel or expansion programs which go on in a welding organization, these trained operators are one source of new personnel.

Each individual plant probably will have different requirements for welding operators; and someone in the plant must be able to evaluate the skill of the welder who applies for work, in terms of the requirements of that plant.

Some sort of a qualification test is the best means of objectively evaluating the skill of a welder, and the administration of such tests to applicants before they are hired is the best method of avoiding disappointment on the part of either the welder or the welding organization in case the welder's skill does not happen to apply effectively to that organization's work.

These tests should be specific to certain general needs of the organization; and while they need not be complicated nor costly, they should consist of the same sequence of operations conducted in an orderly and consistent manner each time a man is tested in order to best serve the needs of the organization.

## Adapting Welding Operators by Training

After new employees have been hired by a welding organization, there is a definite training program which must always be carried out whether it is to train a man who knows nothing about welding to become a welding operator; or whether it is to adapt the skill and knowledge of an already well-trained welder to the special needs of the shop.

One of the most economically productive phases of this training is that of establishing and maintaining good habits of the use of welding electrodes, the orderly and speedy education of the new man in the use of the types of electrodes used in the plant, the types of fixtures, the control, and the other special details of workmanship which make work in that plant different from other welding organizations.

The maintaining of a school (if only a small localized department in the welding shop) for the "polishing off" and special detail education of incoming welders has been found to be a very practical means of getting the new man started.

Another important phase of training is to provide a welding instructor who is available to assist the new man on his first job, or older men when they are shifted to a new operation in the plant. This type of specific instructional supervision gives special training on the job and permits supervision of the control of weld sizes, location of welds, weld sequences and step-wise procedures in a way which gives assistance to the new man when he needs it; and in a way which might not be possible if it were left to the departmental supervisor on the job.

Another good investment in this type of education is the special emphasis on safety in the handling of electrodes and machines in such a way as to reduce the possibility of damage to machines and equipment during their operation, or during the hours when they are not being used. A welding machine, if let turned on and grounded by the lead, is likely to overheat and damage or even destroy the machine or other parts of the equipment. This phase of education is an important one and lends itself profitably to the orderly and scientific approach of the engineering methods.

## Correlating Design with Practical Shop Practice and Equipment

While there sometimes seems to be a tendency to assume that the function of designing welded equipment should be a prerogative of the Engineering Department alone, there are certain considerations on which the common knowledge within several departments of the organization must be pooled and where certain principles should be common knowledge

A pooling of the knowledge of the capacities of machines in the plant; for example, shears for cutting parts from plates, the over-all capacity for flame-cutting units, capacity of bending brakes, rolls or presses, are important items in the production of parts for welding and have a distinct bearing upon certain details of design.

The principle of the relationship of volume of weld metal to increase in lineal dimension of weld as shown in Fig. 7 is also a principle which should be shared alike by the manufacturing part of the organization and the designing engineers. This is distinctly a phase of welding engineering which is significant in both welding design and welding production practice, since it may often be important to know that to cut two pieces of steel and weld them into a structure in such a way that their strength is equal to that of one piece equal to the thickness of the two, yet requiring twice the amount of weld

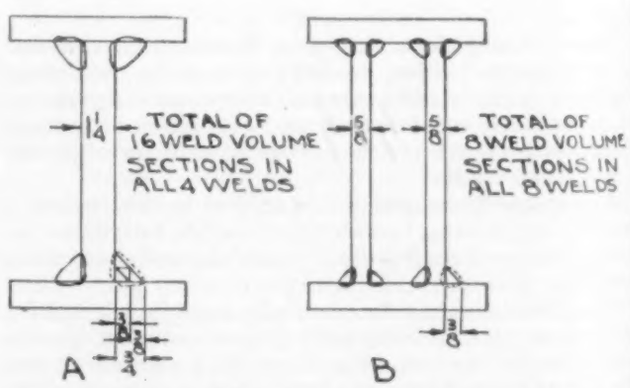



Fig. 7—Fundamentals of Welding Design, Especially a Knowledge of Relative Strength of Welds, Should Be Widely Known in a Welding Organization

In this case the total web sections in *A* and *B* are equal in strength but only one-half the weld metal (and time and cost of welding) is used to fuse the total web section in *B* as is required in *A*, each welded to a comparable strength.

metal to fuse it into the structure and give the same structural strength (see Fig. 7).

It may be that machinery is available which will handle the plates equal to half the total strength required but won't handle a solid plate equal to the strength required. It also may be that the additional work involved in making two of the thinner pieces will cost less money than the deposition of the double quantity of weld metal required for the single thick piece.

The principle of using a bending brake (see Fig. 8) whenever possible in the production of welded structures instead of putting two pieces together and welding them is another general principle which, if it is used as common practice throughout the organization, may often result in simplification of design. If used in the manufacture of the first one or two experimental units before they have been standardized for mass production it may produce real economy in mass production operation.

Another fundamental consideration in the engineering of welding design is the determination and control of the correct amount of welding on certain types of joints. On some kinds of welded units as much as 90% of the joints are of the T joint type, or fillet type joint where the legs of the weld may easily exceed the thickness of the plate to almost any degree to which the operator wishes to deposit metal.

Increases in the size of the weld on T or fillet joints results in increases in volume of weld metal (and cost), by the cube rather than by the lineal dimensions as shown in Fig. 7, so that if the size of a weld is increased only one-half its normal size, over twice the amount of time, power and weld metal are required to weld the joints.

The knowledge of these fundamentals on the part of the organization, in general, tends to lead to more economical welding engineering at the beginning of the design and construction of a new unit in a way which results in considerable economy, since any time a design can be made to cost less, or changes can be made to reduce the cost of welding without reduction in quality or strength of the unit, it is a good piece of engineering.

The weldability of different materials which may be included in design and the relationship of the welding process to the chemistry and metallurgical properties of the materials in the structure are also problems which affect not only the original design of the structure but also involve the members of the organization who are engaged in cutting, shaping, heat treating, machining and other processing of the product.

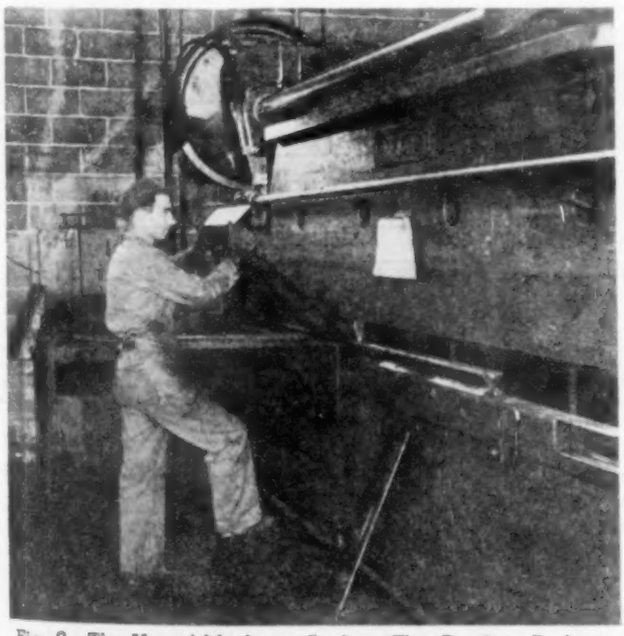


Fig. 8—The Use of Machines Such as This Bending Brake to Reduce the Total Amount of Welding on an Arc-Welded Unit Is Another Important Phase of Welding Engineering

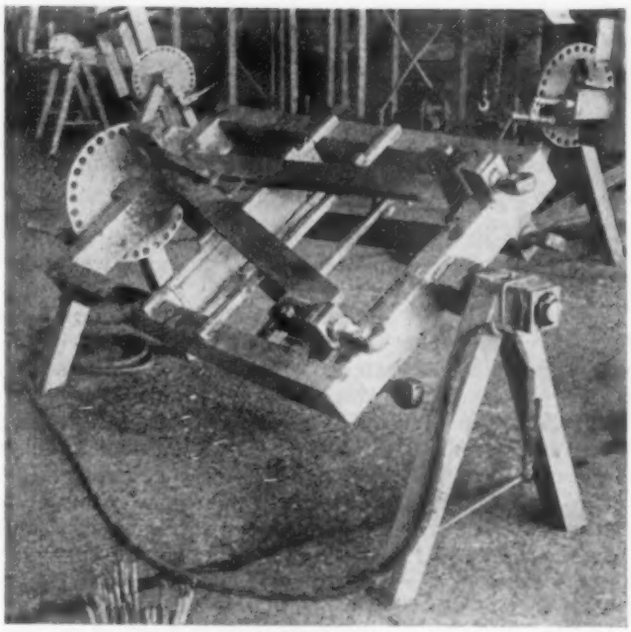


Fig. 9—Building Fixtures Which Speed Up, Standardize and Simplify Setting Up and Welding Operations Is an Important Welding Engineering Function Which Offers Real Sources of Economy

Note the use of premachined parts in this structure, and their protection from weld spatter drops by the fixture.

All of these factors are parts of the general subject of welding engineering and it goes without saying that they are beyond the scope of one man in any large organization.

## Create Fixtures for Setting Up and Positioning for Welding

Each separate welded structure should be studied individually with the object of setting the parts together more quickly, positively and efficiently; and positioning the unit for welding in the most favorable position possible to reduce the total cost of its production. This study also includes the possibility of premachining the parts prior to setting them together and welding them as a phase of welding engineering which is lucrative when objectively studied.

The study of the effect of the heat of welding and the resultant distortion and locked-up stresses is also a part of the studying of the structure and designing of the most efficient fixtures for its production.

Often structures may be made into several substructures in order to achieve more favorable positioning during the welding process (a larger percentage of the welding in the down-hand position) or in order to reduce the handling and increase the ease of machining certain parts which cannot be totally premachined.

The use of time study methods to establish the differences in cost between down-hand welding and horizontal fillet welding or between fillet welding and vertical welding or overhead welding in a particular organization is one of the best means of establishing the amount of added efficiency which can be achieved by positioning welds for down-hand or for more favorable welding during their manufacture. It is commonly found that a reduction in time and cost of welding of from 25 to 50% can be

achieved by the production of a fixture for positioning of welds where some welds have to be deposited in the vertical or overhead position and can be positioned for deposition in the flat or horizontal fillet position.

## Establish Procedures for Welding the Company's Products

After the jigs and fixtures have been built, a general stepwise procedure for the setting up and welding of welded structures naturally follows.

When the product is made on a mass production basis, stepwise check sheets such as shown in Fig. 10 giving the individual steps one after another, including the setting up of the parts and the stepwise deposition of the welds in the proper sequence so as to minimize or control the effect of distortion from the heat of welding should be made up. These check sheets in the hands of the operator give an engineered set of specifications which answer his questions such as, "which part shall I set up first?" and, "which weld shall I make and in what order?" in a way which allows for standardizing of operation and the resultant standardization of products.

In the case of the production of an individual machine or only a few machines, the planning must of necessity be done. Likely this planning will be done by the special set-up man who is building the unit, or may be accomplished by special notes on the print from which the set-up man works.

In mass production operation, or in single-unit production unless there is a stepwise planning of the production unit, the fixtures which may be available for the use in the production of the substructures of structures which go into the unit may not be used to best advantage, and the maximum efficiency which should be developed from having such fixtures will not be realized. This is an important part of welding engineering from the standpoint of economy, and in the interest of controlled appearance and standardized products.

## Organize Detail Welding Control

There are certain phases of detailed control of the welding process which, unless prescribed as written specification are likely to cause variance in processing which will be reflected in variations in appearance of the finished product, lack of interchangeability of parts and also variation in the cost of its production. This is especially true in the mass production of welded products, although some of the specified information must be presented on even solitary unit production.

The details which should be specified comprise the answers to the questions which the welding operators should ask, and have answered in his mind, before he strikes an arc on the structure.

They are briefly as follows:

1. Where should this structure be welded?
2. What size weld should be deposited?
3. What is cross-sectional view or form of this weld when it is finished?
4. In what position should this joint be welded?
5. How many passes (layers) of weld metal should be deposited to make this weld according to best procedure?
6. What type of electrodes should be used for the deposition of each layer of weld metal?
7. What size electrode should be used for the deposition of each layer of weld metal?
8. What machine setting should be used for each separate pass?

The answers to these questions may in part or all be placed upon the blueprint of the structure by use of welding symbols such as shown in Fig. 11.

In the manufacture of a single machine or a very small number of machines, welding symbols may be used on only the major parts of the machines. Here the craftsman who sets up and welds the unit may be a more skilled workman from the standpoint of welding engineering than one normally doing the work on comparable units in mass production of many units where the workman repeatedly does the same operation or series of operations, but does not do the whole job.

In whatever manner this information is imparted, it is engineering work and it is a field of engineering in welding which presents opportunities of control and economy on a considerable scale, especially on a mass production operation.

The establishment of a system for such a control (weld symbols on the blue prints) requires a certain amount of education on the part of the operator in order that the information may be understood and properly followed. This educational work is a phase of welder training which can be standardized by use of AMERICAN WELDING SOCIETY welding symbols (which are widely used), but also require individual plant adaption and running.

| | ELEMENTS | | | | | |
|---|---|---|---|---|---|---|
| 1. | Check in parts | | | | | |
| 2. | Turn,pos.bk.plts.in jig,tack & weld seam | | | | | |
| 3. | Pos.&tack top curved plate | | | | | |
| 4. | Pos.&tack bot.curved plate | | | | | |
| 5. | Pos.&tack frt.plates,tack&weld seam 1st pass | | | | | |
| 6. | Turn,W.frt.plates to top curved plt. | | | | | |
| 7. | Turn,W.frt.plates to bot.curved plate | | | | | |
| 8. | Turn,W.bk.plates to top curved plt. | | | | | |
| 9. | Turn,W.bk.plates to bot.curved plt. | | | | | |
| 10. | Turn,Bolt shv.jig to main jig | | | | | |
| 11. | Pos.&tack apron shv.&single shv. | | | | | |
| 12. | Remove shv.jig | | | | | |
| 13. | Pos.&tack spacer plt.,W.apron shv.to frt.plt.lt.side | | | | | |
| 14. | Pos.tack &weld gusset to spacer,pos.&tack to A frame | | | | | |
| 15. | W.single shv.&gusset to frt.plt.(outs.) | | | | | |
| 16. | W.gusset,spacer & apron shv.to frt.plt.(ins.) | | | | | |
| 17. | W.apron shv.(outs.rt.),spacer & sgle.shv.ins.to frt.plt. | | | | | |
| 18. | Pos.,tack,&weld rt.tailgate shv. | | | | | |
| 19. | Pos.tack & weld brace to tailgate shv.&frt.plt. | | | | | |
| 20. | Pos.tack & weld lt.tailgate shv. | | | | | |
| 21. | Pos.tack & weld brace to tailgate shv.&frt.plt. | | | | | |
| 22. | Turn,W.side of tailgate shvs.to back plates | | | | | |
| 23. | Turn,W.shv.braces to top plt.(1st side) | | | | | |
| 24. | W.spacer plates to apron shv.&sgle.shv.(ins.) | | | | | |
| 25. | Turn,W.shv.braces to top plt.(2nd side) | | | | | |
| 26. | W.apron shv.to top plt.,rt.spacer to apron shv.&top plt.outs. | | | | | |
| 27. | W.lt.spacer to single shv.,apron shv.&top plt.(outs.) | | | | | |
| 28. | W.apron shv.(ins.)to top plt. | | | | | |
| 29. | Turn,W.2nd pass on frt.plt.seam | | | | | |
| 30. | Turn,remove structure to floor | | | | | |
| 31. | W.seams,frt.plts.ins.,back plts.(outs.) | | | | | |
| 32. | W.tailgate shvs.to back plates | | | | | |
| 33. | Aside str.,paint no.,pos. card. | | | | | |
| | | | | | TOTAL | |
| DATE | | | | | JOB NO. | |
| | | | | | UNIT NO. | |

SCRAPER DEPARTMENT
F 8016 LS "A" FRAME
Setup & Weld

TS 306-2

Fig. 10—The Establishment of Orderly Sequence of Operations in the Production of Welded Structures Must Precede Time Standardization and Most Economical Mass Production. This Check Sheet Gives the Sequence of Operations for the Structure Shown in Fig. 3

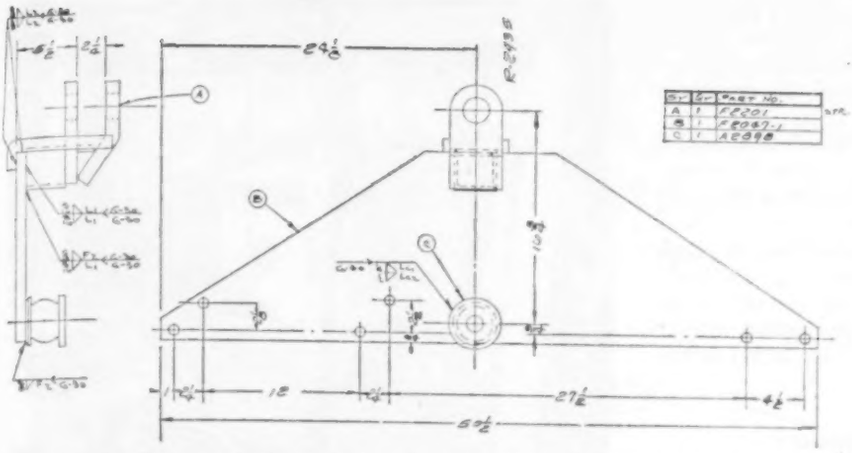


Fig. 11—Arc-Welding Symbols Used as Shown on This Point Form a Very Practical Means of Conveying Engineering Information in Exact and Complete Detail to the Welder, Welding Foreman and Welding Inspector

If this phase of the welding engineering has been accomplished, the degree of control, cost analysis, cost prediction and work scheduling which is necessary for a really successful manufacturing process can be accurately maintained.

Further, with this information in hand it is not at all impossible to establish on the basis of time study standard times for the setting up and welding of structures which can be used on a "production" basis, using an incentive system which allows the welder to capitalize upon his own skill or efficiency of work as commonly established and practiced under ordinary incentive systems.

One additional step must be taken in order to make such a system a success with arc welding, and that is a continual detailed study of the fit-up of the parts on each structure; and a crusade to keep them to a standard which is normal for the structures and therefore is always reflected consistently in the standardized time set for the completion of any given job.

## Establish Quality Control (Inspection)

The problem of quality control in arc-welded products is one which must be solved for each individual organization and each individual product.

If there are complete specifications as to size and appearance and quality of weld, a large portion of the engineering has been done because the process of quality control resolves itself only into determining that the specifications are met.

Whether there are complete specifications or not, welding quality inspection must be practiced on any welding job. Someone in the organization must be responsible for either periodically or 100% checking of the welder's work to control the degree of perfection of the finished product.

Inspection of welded products may be a very highly specialized process, involving special techniques prescribed by code, and requiring apparatus and skilled technicians for its accomplishment. The X-ray, gamma ray, magnetic flux and other special nondestructive inspection methods used on pressure vessels, military equipment and several other applications require a greater degree of specialized training on the part of inspectors than does the simple guided bend test or other rather simple weld qualification tests.

Associated with this checking, there is a process of education of the individual welder as to size of the deposited weld and general qualities of appearance which lie within the operator's control and which may be conveyed to him by the welding supervisor, the welding engineer, the welding instructors, or someone from the Inspection Department. Whoever does the job, it is a phase of welding engineering.

Another type of inspection which is usually very instructive and may be profitable is that of examining structures which have failed in service. Such examinations usually yield certain types of information for welding organization. If certain failures recur frequently, it may be a weakness in the initial design of the structure, or it may be a matter of welding technique. Only by careful examination of the structures which fail can this be determined.

In connection with such examinations it sometimes also may be to the interest of the company and to the individual welders in the organization to have a system set up whereby the work of each man may be identified at any indefinite period after he has completed it, including after periods of field service. This is an organizational problem, but it is also one of welding control which may reasonably be considered to be a part of welding engineering.

## Keeping Abreast of Practice Within the Industry

One of the most important phases of welding engineering in a welding organization is that of keeping up-to-date with the developments and new practices which enter the field.

There is research being done constantly in establishments and by societies or groups of investigators who are qualified and equipped to do welding and associated research. Such research is not necessarily a part of the welding engineering of many welding organizations but it is distinctly to the interest of all companies who are manufacturing by the arc-welding process to keep abreast of the results of such research.

There are several ways in which this can be accomplished. One of the very best is that of reading trade journals in the welding field and metallurgical field which present the technical as well as the practical shop practice aspects of current production. A thorough and regular examination of the leading literature of this type goes along toward keeping an organization informed as to the development within the field.

Another very effective means is that of supporting the AMERICAN WELDING SOCIETY where the journal and technical services published give very complete and detailed coverage of the results of research in the welding field.

The local section meetings of the SOCIETY also are very good sources for instruction since they are primarily dedicated to the forwarding of the arts of welding and metallurgy and commonly have specialists in the field to address the members of the local section upon the subjects which they are most capable of discussing by virtue of their past experience in the field.

Another very profitable phase of the local technical society meetings is that the meetings bring together local members of industry and bring about an exchange of ideas and an acquaintance with each other so that an interplant exchange of ideas may be accomplished.

Still another important means of keeping up-to-date with what is going on in the fields is that of visiting plants in different parts of the country which are engaged in

manufacturing products similar to those being made by any particular company. Usually such visits of people from one plant to another are of mutual value because of the exchange of ideas within the scope of the common practice within the plant.

Another importance source of information is that of the engineering service which is given by vendors of equipment for arc welding. The manufacturers of equipment are busily engaged in research which will improve their product and therefore increase the effectiveness of their unit for manufacturing by the arc-welding method; and although usually these engineers are interested in promoting their own products; the information which they give is usually associated with fundamental welding problems.

### Who Then Is a Welding Engineer?

The problems of describing just what the welding engineer should do have been more or less outlined by the description of the engineering problems encountered in welding.

Obviously no one man can accomplish all of the welding engineering details nor properly supervise all of the various phases of the welding engineering problems in a large plant.

However, it may be said that any one who is actively and successfully engaged in the solution of the welding engineering problem is doing welding engineering work.

It is impossible to describe exactly what all of the qualifications of a welding engineer should be, but there are a few which may be outlined—three of the most important of which are as follows:

*A.* The welding engineer should have a preponderance of interest in shop outlook, as opposed to the "white-collar" job. The organization of the procedures and control and the knowledge of the processes and operation in the plant must come from a first-hand shop knowledge which cannot possibly be obtained from "front office" study; and the administrative problems which come with welding engineering can seldom be administered 100% by swivel-chair office practice.

*B.* The welding engineer must know the physical layout of the shop in which the welding is being done, the names of the units produced and their parts, the names of the fixtures which produce them, the general language of the shop and the procedures which are being carried out in detail, and must be able to think clearly and objectively in order to organize the information and solve the problems arising in the welding phases of the plant's work.

Since the welding engineer's work is, in many respects, correlative and educational, the degree of success of the specifications and the procedures which must be set up to control the welding process properly depend upon the cooperativeness of all of the members of the organization involved. This makes it necessary for the welding engineer to know the members of the organization and, to be known by them.

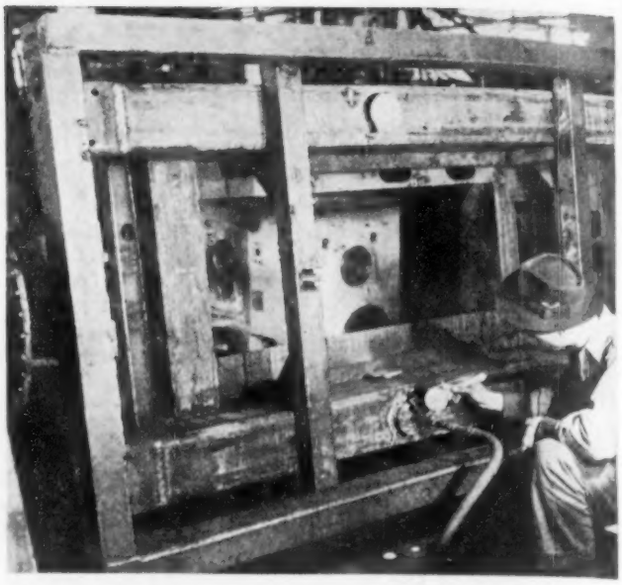


Fig. 12—The Testing of the Fuel Tanks in This Welded Structure with Air Under Pressure and Soapy Water Represents One Way of Proving Quality Control for This Special Application. Inspection Is a Necessary Phase of Welding Production and Warrants Study and Careful Engineering

*C.* It is a very important phase of the welding engineer's successful functioning in an organization to be tactful and capable of getting along with people, capable of carrying responsibilities and capable of promoting programs of organization and control within the company's organization.

The educational background of a welding engineer does not necessarily mean the graduation with a university education in welding engineering. That phase of the development of the welding art and industry, and education has not been developed to the extent that full-fledged welding engineers may be produced by the universities or institutions of higher learning in large numbers, although the technical information and training required to solve many of the more difficult problems which arise in a large or very specialized organization for the production of welded products does require the learning of information which is usually obtained in institutions of high learning.

Whatever the educational background may be, men successfully involved in welding engineering always have had sufficient shop experience to get them acquainted with the various factors and unsolved problems within their own organization.

# Resistance Welding Laboratories and Their Instruments*

By R. T. Gillette†

SHOULD a manufacturing company have its own Resistance Welding Laboratory, or should it depend on various outside sources for its information?

Certainly a Welding Laboratory for obtaining information first hand is a definite asset, if not an absolute necessity, since information collected at random may be inaccurate and may not apply to the problem at hand.

What are the functions of a Welding Laboratory? Perhaps we should give a brief outline:

1. Assist the Engineering Department in the design of products, and prove this design by samples and tests.
2. Collect data on physical properties of various types of welds.
3. Determine weldability of materials selected for any given job.

* Paper for Second Annual Welding Conference, Rackham Memorial Building, Detroit, Mich., May 4, 1945.

† Works Laboratory, General Electric Co., Schenectady, N. Y.

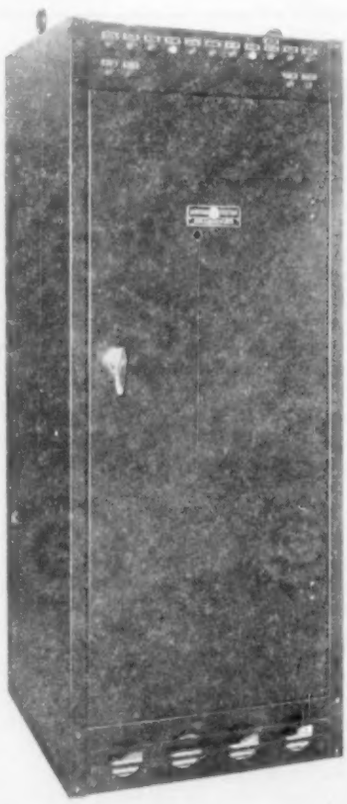
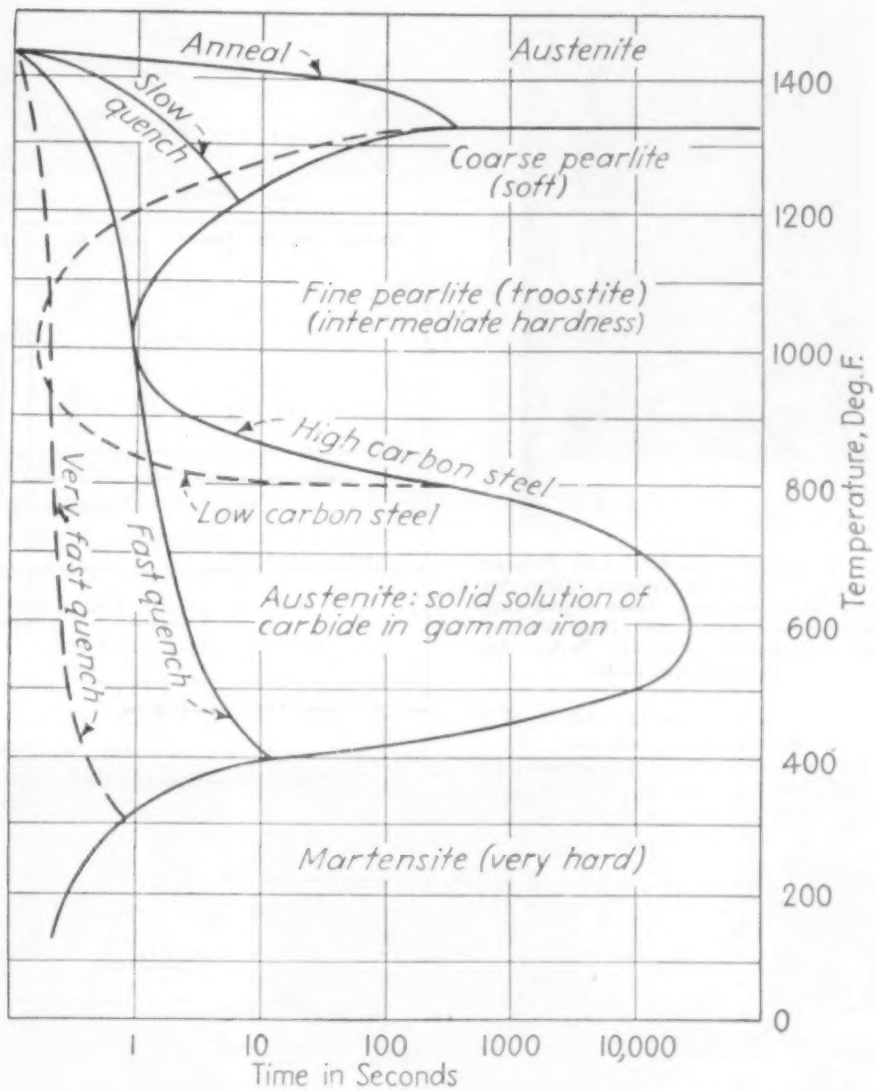


Fig. 1—Sequence Control and Program Timer for Use with Ignitron Contactor, Heat Control and Regulating Panel




Courtesy American Machinist

Fig. 2—These "S-Curves" Show the Effect of Various Rates of Quenching Upon the Hardness of Low- and High-Carbon Steels. The Aim of the Flame-Hardening Process Is to Avoid the Normal Transformation of Austenite Into Pearlite and Ferrite (See Fig. 1) and to Produce the Very Hard Phase Known as Martensite. This Transition Is Accomplished by Fast Quenching

4. Determine weldability of all types and classes of engineering materials in like and dissimilar thickness combinations, as well as like and dissimilar metal combinations which will be used in the company.
5. Set up data and procedures required for various qualification tests, inspection procedures and quality control methods.

Two very good papers have been published on quality control, one in the January 1944 issue of THE WELDING JOURNAL, by N. C. Clark of the Lockheed Aircraft Corp., and one by L. S. Hobson, R. S. Inglis and R. P. McCante, all of the General Electric Co., in an A.I.E.E. Technical paper, 45-98, March 1945.

6. Make metallurgical examinations and both micrographs and macrographs to determine penetration of welds, their soundness, hardness, freedom from defects and

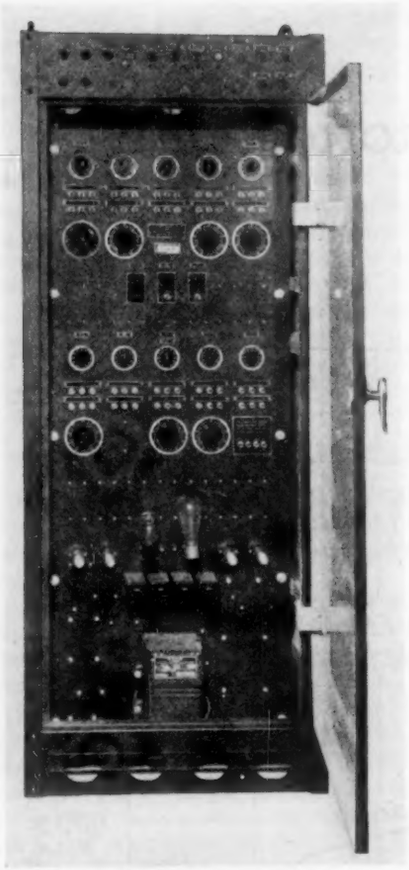


Fig. 3—Sequence Control and Program Timer for Use with Ignitron Contactor, Front View Showing Door Open, and Showing Indicating Lights, Time and Current Adjustments, Pressure Period Adjustment and Tubes

suitability for the job from a metallurgical standpoint.

7. The use of X-ray equipment may also expedite the study of some welds.

8. Where preheat or postheat treatment is required on various heat-treatable materials, the correct procedure should be worked out in the Laboratory, and complete data prepared for the factory.

What equipment is required for a Welding Laboratory?

This is a most difficult question to answer, since it is controlled by the type of work required. It may consist of a few pieces of simple equipment, or it may be a very complicated and extensive equipment, depending on the type of welding and test requirements.

First of all, we should have several types and sizes of resistance welding machines if we are to do a large variety of welding. (It is very difficult to do developmental work on production equipment since production requirements will necessitate frequent interruptions). This equipment may vary from a simple spot welder and control to a complete line of welding machines.

There should be spot welders of several sizes, from the miniature bench type with electrode force as low as 8 to 10 oz. with $^1/_2$ kva. capacity through at least four sizes, to a large one capable of giving at least 20,000 lb. electrode force and capable of delivering 100,000 amp. or more.

In addition, there should be both a large and a small universal seam welder and also a capacitor and a magnetic stored-energy spot welder, and about four or five butt or flash welders, ranging in size from one about $^1/_2$ kva., manually operated, one purposely built for wire, one cam operated for sections up to 1 sq. in., and a hydraulically operated one with capacity up to about 6 sq. in. of low-carbon steel. Other types of welders to fit a certain type of manufacture may also be needed.

All these machines should be equipped with the latest electronic controls. At least one of the larger spot welders should be equipped with a program control for preheating and postheating heat-treatable materials (Fig. 1). A description of this control and its functions may be of interest.

We are required more and more to fabricate products involving the welding of hardenable steel or air-hardening steel—that is, steel that will become hard and brittle when heated above the critical range and cooled rapidly.

The curve illustrated in Fig. 2 is what is

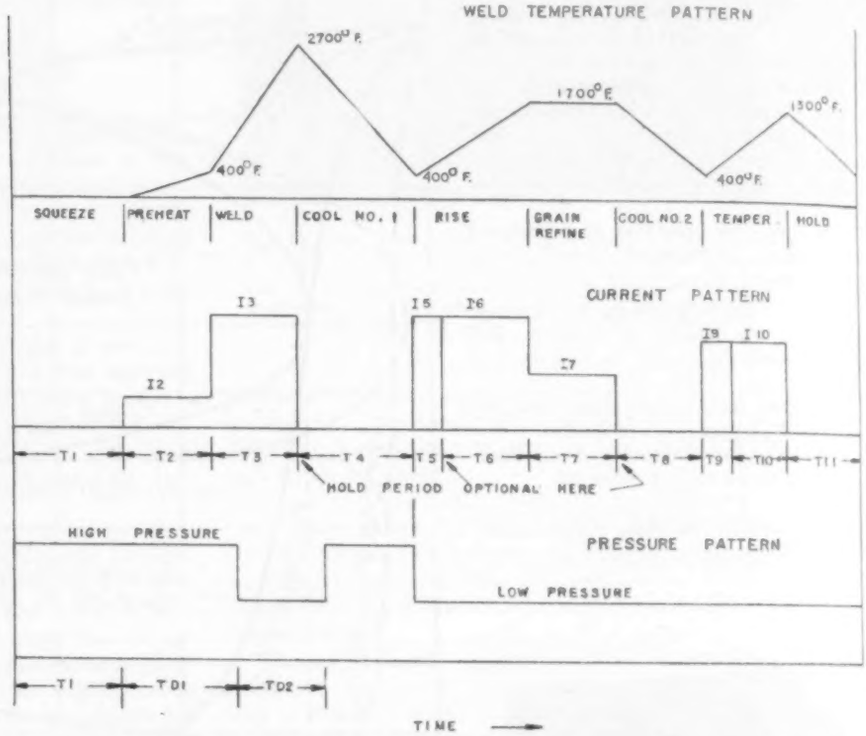



Fig. 5—Typical Heat-Treating Cycle Obtainable with Program Timer and Sequence Control

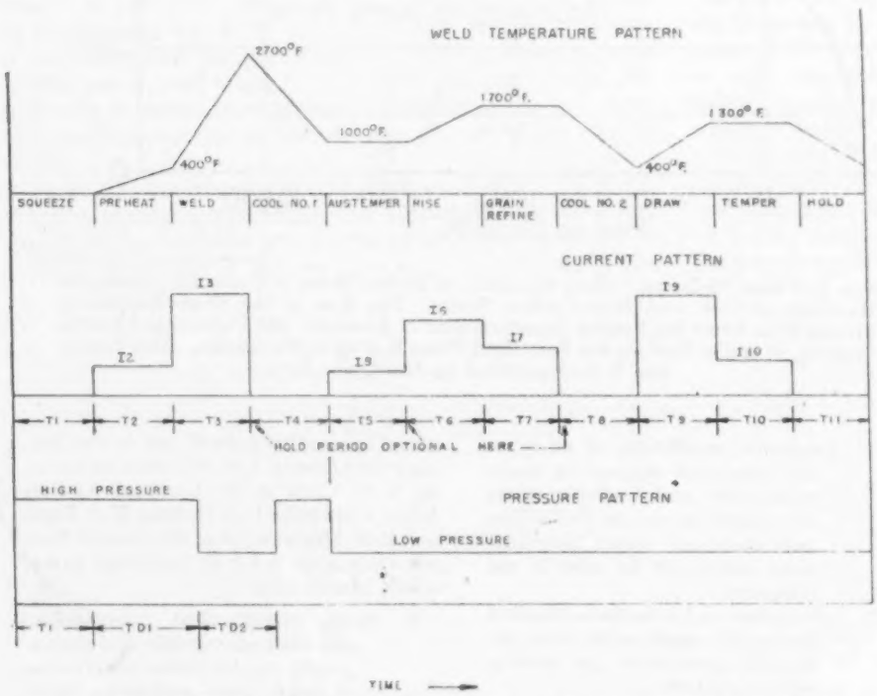
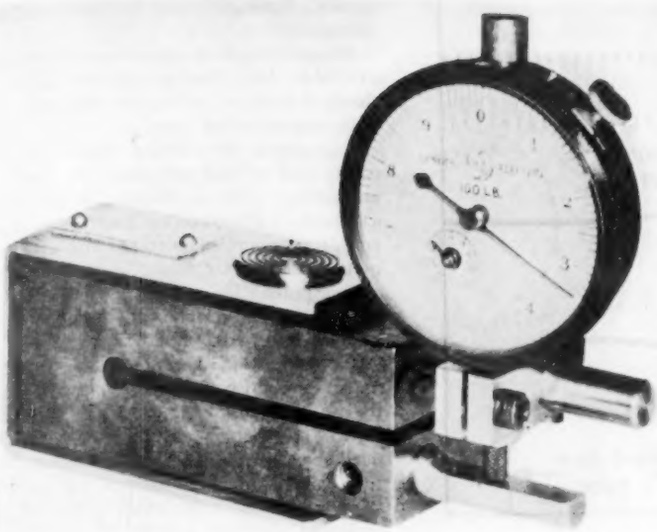
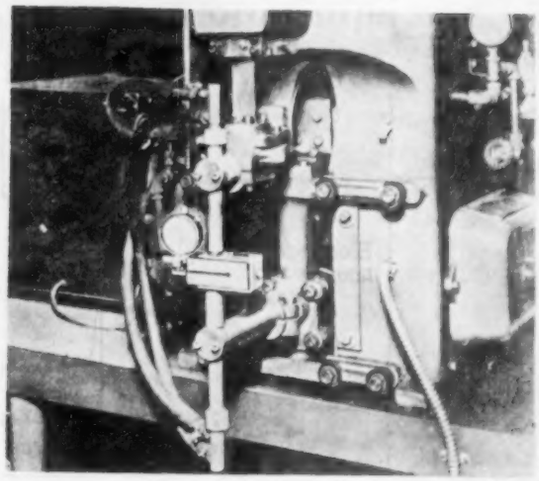
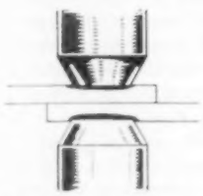


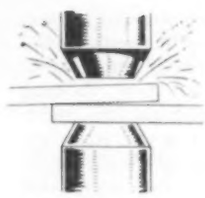

Fig. 4—Typical Heat-Treating Cycle Obtainable with Timer and Sequence Control







If force is too great---
Contact resistance is too low
Not enough heat is produced
Result a weak weld



If force is too little---
Contact resistance is too great
Too much heat is produced
Result: surface indentation, spattering, and arcing

1. Measures force in pounds between electrodes of a resistance-welding machine
2. Helps increase production and improve quality of welds
3. Simple, sturdy construction
4. Range 0 to 4500 pounds
5. Accuracy 1 per cent of full scale

Fig. 6—Electrode-Force Gage

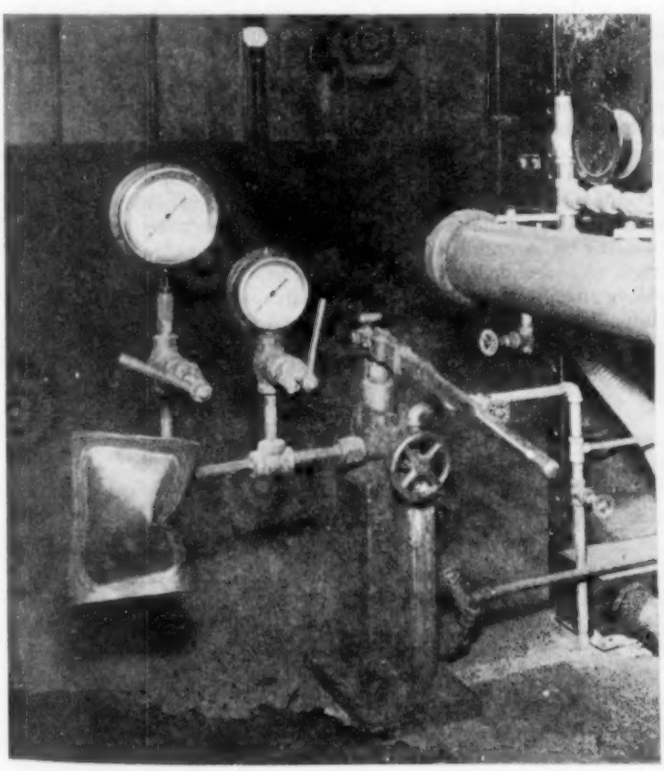


Fig. 7—Hydraulic Equipment for Testing Seam Welds

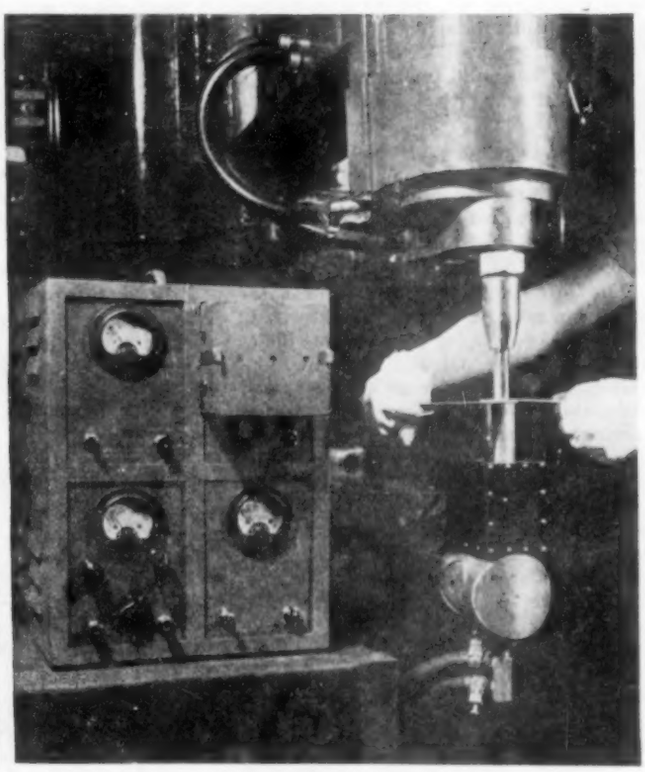


Fig. 8—Close-up View of New Current-Force Recorder in Operation

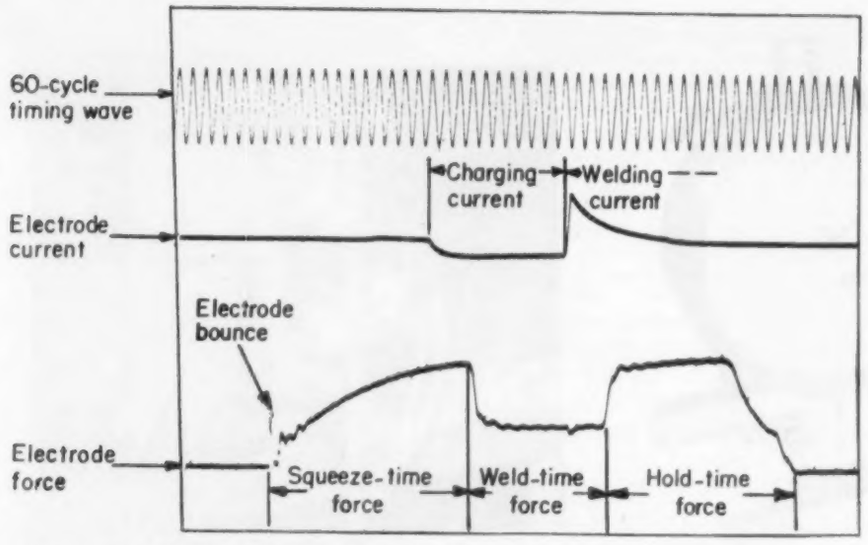



Fig. 9—An Oscillograph Record Obtained with the Current-Force Recorder

commonly referred to as the "S" curve. It clearly reveals what structure will be attained in a steel when it is cooled at a specified rate to a definite temperature. If the "knee" of the curve is far enough to the left, we do not have to concern ourselves too much with the cooling rate, or the temperature to which it is cooled, because it would require an infinitely fast cooling rate to get below the "knee" before transformation started and, in some cases, completed. However, if the curve moves to the right, because of carbon content or alloying elements, extremely slow cooling rates, or cooling to very definite temperatures, is necessary to retain a steel that is not too brittle for engineering applications. In other words, if we make a spot weld in the conventional way in a hardenable steel, the weld area having been well above the critical temperature and given a drastic quench, as in the case between two water-cooled electrodes, the result is a hard and brittle weld which is liable to fall apart if subjected to shock or vibration. Such welds must be heat treated to produce the required physical properties.

To permit the welding of such steels and automatically give the required heat treatment, an electronic control has been developed (Fig. 3).

The indicating lights at the top of the control panel will indicate which step in the sequence is being performed. Below are shown all the controls. The panel consists essentially of a group of timers and phase-shift circuits so grouped and sequenced that they provide eleven distinct time intervals and seven different heats (Fig. 4).

A preheat period is provided which will permit preheating if the section is so large as to make this necessary. Then the weld period is followed by the cool, austemper, rise, grain refine, cool No. 2 draw, temper and hold periods, respectively. At maximum time setting on all intervals, a time of 203 sec. will elapse between start and finish.

Here, as the weld is completed, it is allowed to cool to approximately 1000° F. It is held at this temperature sufficiently long to allow complete transformation to take place. We have here a definite grain structure offering definite physical properties. This structure can be predicted by the "S" curves, previously mentioned. The curve progresses from there, showing the possibility of further grain refinement and, therefore, different grain structure with another set of definite physical properties. Finally, we have the draw and temper, which provides a means of attaining required physical properties without materially changing the grain structure.

Shown in Fig. 5 is another typical heat-treating cycle obtainable with this control. It demonstrates how one period may be blended in with a succeeding period to shorten the complete cycle. The type of steel and the requirements as to physical properties and grain structure will determine what heat and timing to use. For instance, an austempering period would be particularly useful on a steel requiring considerable preheating thus preventing sudden cooling from the welding temperature, which might cause cracking in the weld. Also, the draw and temper periods may be blended together, depending upon the steel and the required physicals.

The greatest advantage of this type control is that it offers the possibility of heat treating the weld area only. Also, it makes possible the use of welding on assemblies that would not permit subsequent heat treating because of size or shape.

After we have equipped the Laboratory with the required welders, we will also need various testing equipment and instruments. Again, this may be simple or quite elaborate.

Physical testing equipment should be available for testing, tensile strength, shock resistance, vibration tests and perhaps other similar tests.

Equipment for cutting, mounting, polishing and etching specimens for their examination with a microscope must be available. Photomicro and macrograph equipment enables us to prepare a permanent record of our work.

Equipment for testing hardness is also necessary. This equipment is so well known that no description is necessary.

We should also have access to chemical and spectrographic analyses service, since its use is many times imperative. Instruments of various other types are also needed to measure or record various factors. Some of these factors are too well known to need description. A brief description of others may be of interest.

Ampere square second recorders are available to measure consistency of weld energy. Equipment to measure surface resistance and determine if material has been properly cleaned for consistent welding has been developed in several different types. Where machines are not permanently equipped with CT and ammeter, clamp-on CT and pointer stop ammeters are essential. Indicating voltmeters with high and low voltage ranges are essential instruments.

A recording voltmeter to study line voltage conditions should also be provided, use may be found for a recording ammeter as well as a recording wattmeter. An electrode force gage (Fig. 6) is absolutely necessary, as the electrode force is very critical on many jobs. Considerable use may be found for temperature measuring and recording instruments. Simple hydraulic equipment (Fig. 7) for making pillow tests of seam welds is of considerable importance to test for pressure tightness and strength.

One of the new instruments that has recently been developed by General Electric is a current-force recorder to measure and record electrode force and current (Fig. 8).

This current-force recorder includes an oscillograph which records simultaneously a timing wave, the rapidly changing electrode force, and electrode current of a resistance welding machine while making a weld (Fig. 9).

The instrument is useful for periodic checking of welding-machine performance and for welding research. The records are especially helpful to users of energy-storage

FF-673-E (7-61)new

RESISTANCE WELDING DATA

Drg. No. _____ Name _____ Works _____

Type of Weld _____ Material _____

Instructions _____ Surface Preparation _____

Top Elect. _____ Change Every _____ Welds

Bottom Elect. _____ Change Every _____ Welds

Fixture _____ Location _____ Filler Mat. & Flux _____

| DATE | MACH. NO. | BLDG. & DEPT. | MACH. SPEED | WELDING PRESSURE | TRANS. TAP | HEAT DIAL | WELD PRI. AMPS. | TRANS. RATIO | WELD SEC. AMPS. | SHORT CIR. AMPS. | WELD TIME | | | INSPECT. DATE WELDER OR PANEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | ON | OFF | FUL | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

Fig. 10

welding machines to determine when forge pressure is applied to the work with respect to the discharge of welding current.

The record also shows squeeze time, the duration and magnitude of welding current, the rate of rise of forge pressure, and the hold time. Two extra galvanometers may be added to record the instant of various relay operations in the control circuit.

A standard method of recording all these data is essential. Shown in Fig. 10 is such a method.

While a complete welding laboratory may seem rather formidable in some cases, if we are to progress we must learn and use the basic fundamentals which pertain to welding, forget our cut-and-try methods, and base our welding on fact rather than on opinion. The establishment and use of complete welding laboratories seems to be the logical way of obtaining these results.

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(*Continued from page 817*)

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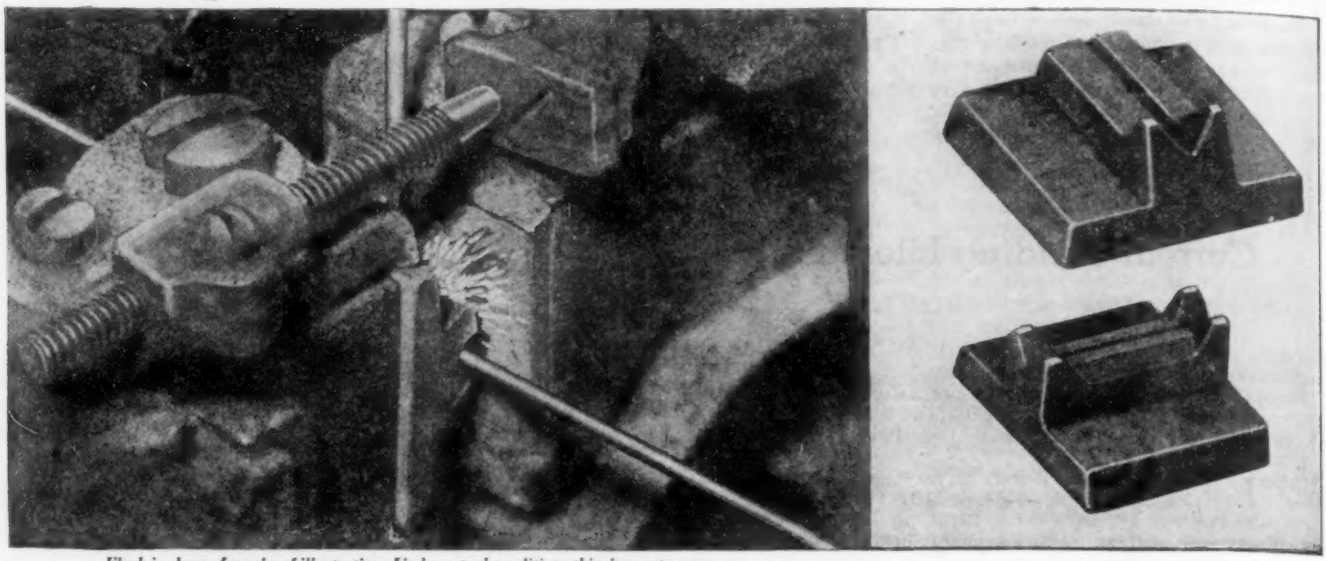

*Flash is shown for sake of illustration. Under actual conditions this does not occur.*

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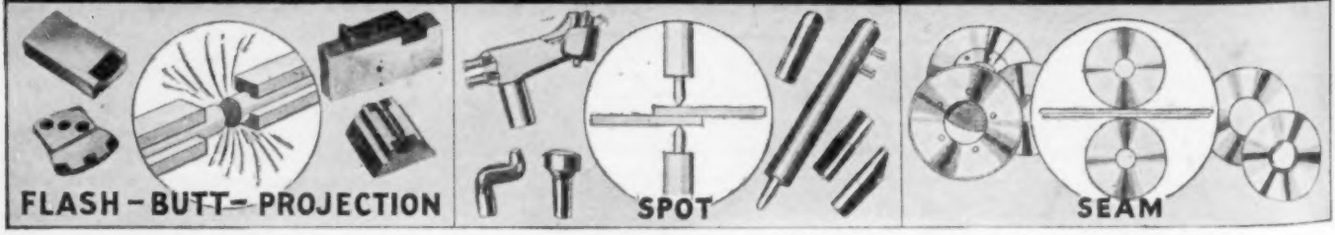

# Machine Gas Cutting

By R. M. Dennis*

MOST everyone today is acquainted more or less with procedures, templates, tolerances, inspection, pressures and speed in flame cutting. This knowledge, no doubt, is the result of experience and innumerable papers which have been published over a period of years covering practically every phase of machine flame cutting. Consequently, little can be written at this time that would not be a repetition, at least in part, of something that has been presented in the past. However, a discussion of some of the innovations and accessories that have been devised and developed for use in the Flame-Cutting Department of By-Products Steel Corp., division of Lukens Steel Co., Coatesville, Pa., may be of interest and some value.

Because of the demands of the war effort, the facilities comprising Plant 4, devoted entirely to flame cutting of shapes from steel plates of varied analyses of both carbon and alloy steels and sizes up to 12 ft. 0 in. in width or 26 in. in thickness, have been so enlarged that production has been increased approximately 100% over that prior to 1942. At the present time two large buildings making up Plant 4 are equipped with eight multitorch travograph and four multitorch oxygraph machines as well as four one-torch pantographs in addition to radiagraphs and cameographs.

* Assistant to the President, By-Products Steel Corp., Division of Lukens Steel Co., Coatesville, Pa.

## Practical Work Table

One of the most practical innovations in Plant 4 is the table which has been designed to hold material while it is being flame cut. This table is just as important as the flame-cutting machine itself, for unless material is supported properly, the most finely designed flame-cutting machine ever made will not produce a precision flame-cut piece. Experience has shown us the value of a number of ideas which might be borne in mind when designing a supporting table of this type. First, the table itself should be set on a solid foundation to reduce vibration to the very minimum. Second, the table should be of solid construction for the same reason. Third, the table should be of such size that it will allow maximum flexibility for operation and will not be cumbersome. It should not be too wide for easy access to narrow material. Fourth, the design of the top of the table should be such that as the supports are burned out they can be removed readily and replaced with new ones. Fifth, provisions should be made to keep the table level at all times.

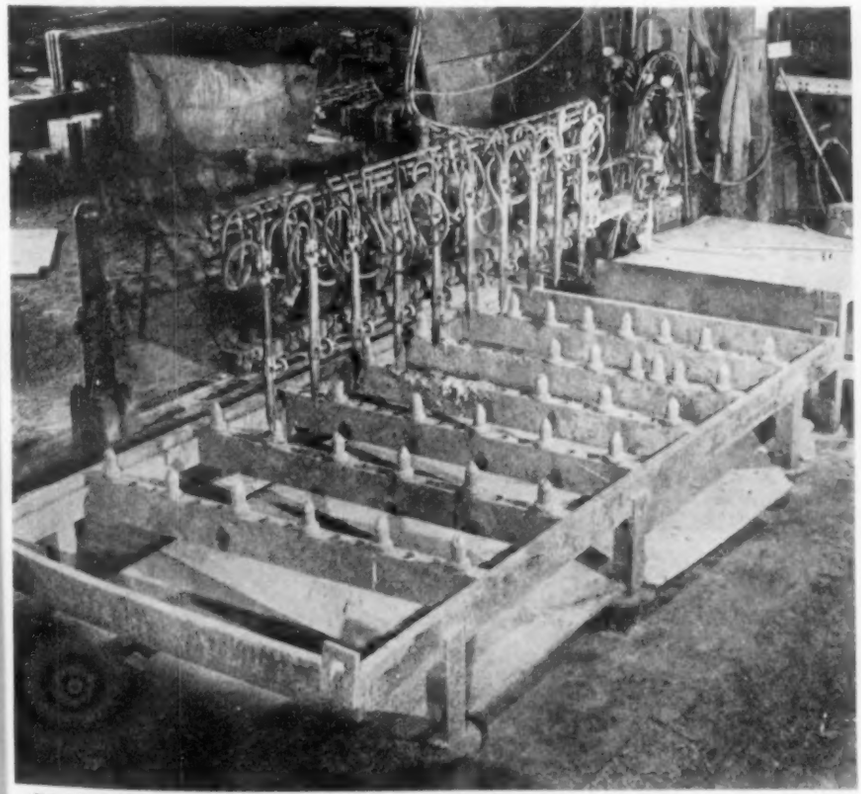

Fig. 1—A View of Stationary Table Showing Sloping Plates Beneath the Support Bars. As the Cut-Out Pieces Fall Through, These Sloping Plates Permit the Pieces to Be Pulled Readily to the Front of the Table

Figure 1 shows a stationary table which has proved satisfactory. This table is a rigid frame of angle construction with removable cross bars machined to size in which pins, or studs, are inset. The space between the cross bars can be changed simply by moving them back and forth on the side rails. The location of the pins in the cross bars also can be varied so that the table itself can be set up to suit either large or small flame-cut patterns. The pins, of cast iron, are symmetrical around their center line with both ends pointed so that when one end of a pin, because of burning, becomes unfit for use, it may be reversed in the hole to give maximum use. The advantage of this pointed design is that the pins can be placed to minimize destruction from the flame of the torch during cutting operations. The table sits on adjustable supports which rest on concrete bases, and by regulating screws in each leg, it can be kept level at all times. Experience has shown that the manner in which the plate is supported during the cutting operations has much to do with the accuracy of the finished job. Proper location of the supports will counteract, to a large extent, shifting which might take place in a piece during cutting operations.

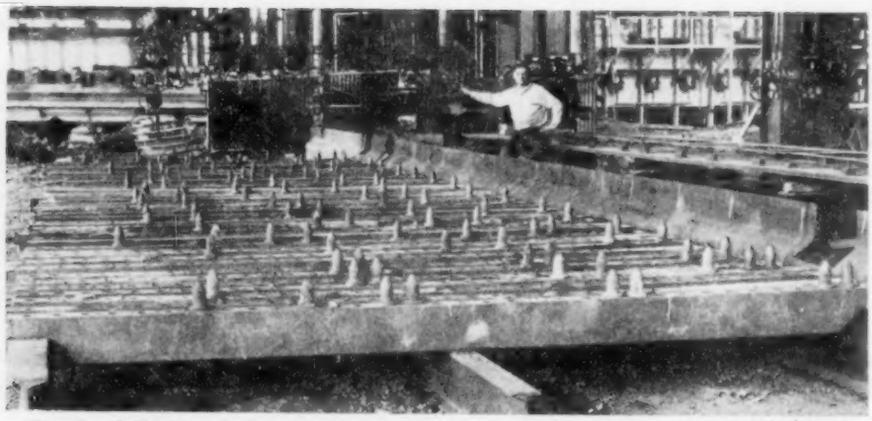

Fig. 2—A Table with Pin, or Stud, Supports in Position Ready to Receive the Steel Plate Prior to the Flame-Cutting Operation

Two 15-in. parallel equidistant I-beams serve as main supports and on top of these, cross members 4 in. thick x 7 in. wide x 12 ft. 0 in. long, are placed. The ends of the cross members are drilled and fitted to the I-beams with clamping plates. With this clamping arrangement, cross members can be moved along the I-beams if necessary. The steel plates rest on removable studs, or pins, during cutting and these studs are fitted into holes drilled into the cross members at 4 in. intervals. The studs with $3^1/_2$-in. diameter collars are inserted in holes and tack welded. When removal is necessary, a blow from a sledge hammer will loosen them.

The cutting of locomotive side frames has shown the advantage of this type of table. These side frames presented a difficult problem because of their many openings with resulting little area for supporting them. Figure 2 shows the table with the stud supports in position ready to receive the plate previous to the flame-cutting operation. Figure 3 shows two frames in position after being cut from $5^1/_2$-in. thick steel plate. This type of table allows the steel plate to be supported fully so that the scrap has free movement to a marked degree, a very important factor in flame cutting. These tables which have been in use for several years have proved to be versatile and flexible. With them it is possible to arrange the supports in minimum time so that any size steel plate can be supported properly for flame cutting.

An alternative type of work table, made with removable supporting strips, instead of pins, 6- x $^3/_8$-in. gage, has proved practical for flame cutting when ordinary tolerances are satisfactory. Where closer tolerances are required, the fixed table with the pins, or studs, is to be preferred. The tables with the strips, measure 5 ft. square, and are portable. Thus, if the plate to be flame cut is too large for a fixed table, several portable tables may be grouped so that the plate to be cut is supported adequately.

As the strips are burned away, they may be removed readily, either singly or in multiples. Ofttimes, though, the strips can be turned over and used again without replacement, thus obtaining maximum utility. The strips are kept in position by inserting them edgewise in slots, which are cut into cross bars.

The floor in front of the flame-cutting machine is of amesite, a bituminous paving, over concrete, so that should a heavy plate fall on it, the plate's edges would not be burred or would the floor be broken. Amesite being resilient would absorb the shock. Besides it is less tiring to workmen than concrete. Also, concrete tends to disintegrate under heat of flame-cutting machines. Though amesite may be softened by heat it is rarely damaged to the extent that new flooring is necessary.

Because of the relative softness of amesite, the work tables are supported on inset plates set on concrete which keep the tables in line. This alignment of tables provides suitable alleys so that scrap can be removed readily and the space adjacent to the machine kept clean.

In Fig. 1 the table is shown with sloping plates beneath the support bars. As the cut-out pieces fall through, these sloping plates permit the pieces to be pulled readily to the front of the table.

## Multiple Torch Cutting

Originally, multiple torch machines were designed with hoses running from the gage to each individual torch, with the result that a tremendous quantity of hose had to be carried on the cutting bar of the machine. The more torches used, the greater the weight. By-Products adopted a plan of using a manifold on the cutting bar of the machine and the long lengths of hose to each torch have been replaced by short lengths, without minimizing effectiveness. The manifold has the economical advantage in making possible the use of a larger number of torches on the cutting bar as well as saving in hose. Figure 4 shows a machine equipped with the manifold which has had practical application for some time. The manifold has two sets of three pipes, and in one pipe of each set are, respectively, preheating oxygen, natural gas and cutting oxygen. The manifold is so designed that for ten outlets to the right of center, gases are supplied through three lower pipes. For ten outlets to

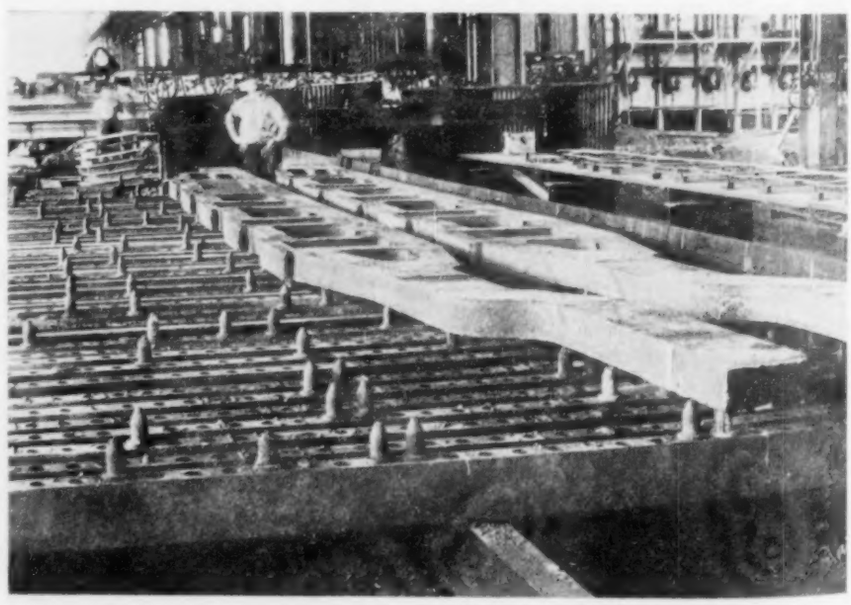

Fig. 3—Two Locomotive Side Frames, Cut from $5^1/_2$-In. Thick Rolled Steel Plate

In positioning the plate before cutting, allowance is made for corridors or waste strips between individual frames to prevent detrimental movement during cutting. The strips are supported by longitudinal angles to prevent their falling on the cross members and jarring the flame-cutting operation.

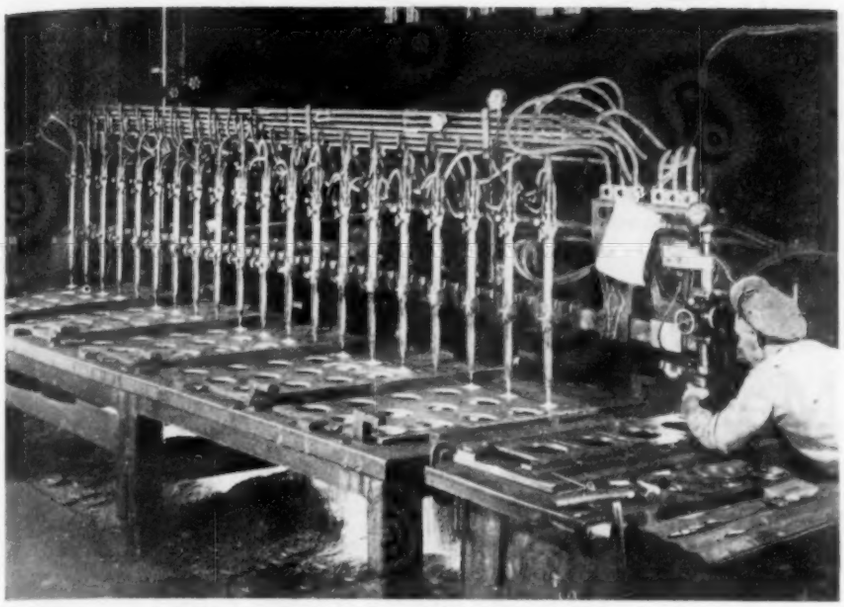

Fig. 4—Oxygraph Machine Equipped with Manifold So That a Number of Torches Can Be Placed on the Cutting Bar

Unused connections are sealed with pipe caps. The manifold permits the use of short lengths of hose connection instead of long lengths from the gage to individual torches.

the left of center, gases are supplied through three upper pipes. Thus, by introducing gases at either end of the manifold, and in six pipes, more steady flames are secured with less fluctuation than if gases were introduced at one end of the manifold and in only three pipes. Three valves on each torch also help minimize variations in the flow of the gases.

This manifold is so designed that any number of torches up to twenty can be placed on the cutting bar; the unused connections being sealed with pipe caps.

## Strainer Plates

Figure 5 shows the cutting of slots in strainer plates for ships. First, the ends of each slot are drilled and the connecting material between the two holes is cut out individually with a specially designed double tip which removes the metal in one flame-cutting operation. This special tip makes two simultaneous parallel cuts of the same width as the diameters of the drilled holes, so that the cut-out part is a small rectangular block with concave edges instead of melted lumps of slag.

This special tip is made from three regular tips. The lower parts of two of them are brazed together and spaced so that parallel cuts of a specified width can be made simultaneously. The upper section of the third tip is brazed to the other two tip parts, making a three-in-one arrangement which does a very neat and satisfactory job. It is an excellent example of what can be accomplished by redesigning parts of flame-cutting equipment when necessity demands. Through the use of this device, production on one particular job has been increased seven-fold.

## Beveled Edges

In many parts for use in welded construction a large number of beveled edges are required. Occasionally these bevels are made by machining, but a large per-

Fig. 5—Cutting Out Slots on Ship Strainer Plates Using Specially Designed Dual Tip. The Ends of Each Slot Are Formed by Drilling and Metal Connecting These Holes Is Removed by This Type Tip in One Flame-Cutting Operation

Fig. 6—Beveling a Part for a Weldment with a Hand Torch, Showing Layout Bar Which Is Used to Maintain Proper Degree of Bevel

centage of them may be formed by flame cutting. In the latter instance, bevels can be shaped either by machine flame cutting or with a hand torch.

A typical example of hand torch beveling is shown in Fig. 6 which also pictures the setup used in performing the work. The illustration shows the layout bar which acts as a guide for the operator so that the proper degree of bevel is maintained.

Just a few of the ideas that have been developed at By-Products Steel Corporation during the last few years have been described in this paper. But we feel that they show what can be accomplished by ingenuity. Unlimited possibilities in this field still exist.

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# Alloy Welding Wire from Powder Metallurgy*

By F. G. Daveler† and P. H. Aspen†

## Introduction

THE use of powder metallurgy, to form machine parts that are difficult or impossible to produce by conventional methods of casting or machining is well known and quite widely accepted.

Generally speaking, powder metallurgy consists of selecting the desired materials as to chemistry and particle size and pressing the metal grains in a die the exact size of the desired finished piece. The pressures used to make many of the powdered metal compacts vary considerably sometimes exceeding 75,000 psi., depending upon the material used. After compacting, the pieces are sintered in an atmosphere controlled furnace at temperatures approaching the melting temperature of the powder. Sintering, again generally speaking, is an atomic reaction which due to the pressure and high temperature fuses or welds the tiny particles to each other.

The engineering staff at "Associated" has for a number of years acted as consultants, designers and manufacturers of equipment for the compacting and sintering of powdered metal products. As a conjunctive activity they have designed and built processing equipment for the welding rod industry.

## Alloy Welding Rod

Realizing the need in the special alloy welding rod field for wire alloyed of elements difficult to produce by normal rolling and drawing, and the need for a cheaper method of producing stainless steel welding wire, Associated engineers conceived of and developed a method of producing, through the media of powder metallurgy, a rod composed of any desired analysis. The finished rod is capable of being coated with any of the usual a.-c. or d.-c. welding rod fluxes and used in the same manner as any coated rolled and drawn welding rod.

All of the work was done under the supervision of A.I.E., Inc., with such firms as Dupont and Metals Disintegrating Co. participating with advice and special materials.

Much of the early work was done in a crude fashion, and with equipment poorly suited to the job; however, when the project appeared to have the earmarks of a successful enterprise, ample equipment and properly designed dies were made available.

The finished unfluxed synthetic welding wire presents the appearance of a welding rod coated with a dark metallic-appearing case. Actually it is a small diameter base wire encased within a cladding of powdered metals.

The base wire is generally made up of that element which will comprise the majority constituent of the finished weld deposit; for instance, in stainless steel the predominant element being iron, the base wire would be iron and the cladding nickel, chromium, manganese, etc. Over the cladding is dipped or extruded a second coating of welding flux, as in the normal production of welding rod, and the rod is ready for use.

## Synthetic Rod Production

Figure 1 shows the necessary steps for the production of a synthetic welding rod. In making synthetic 19/9 (Type 307) grade of welding wire, a base wire of ingot iron (0.03% carbon) is clad with sufficient powdered low-carbon ferrochrome, pure nickel, ferromanganese and ferrosilicon to combine under the welding arc with

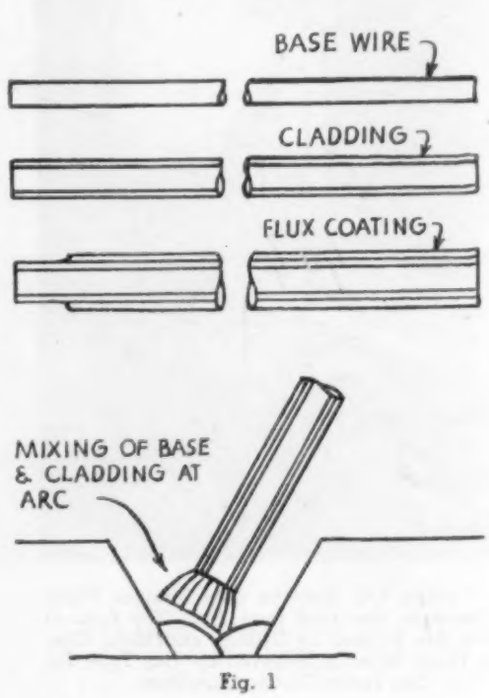



Fig. 1

* Patents applied for.

† Director and Vice-President, respectively, Associated Industrial Engineers, Inc., 1505 Race St., Philadelphia 2, Pa.

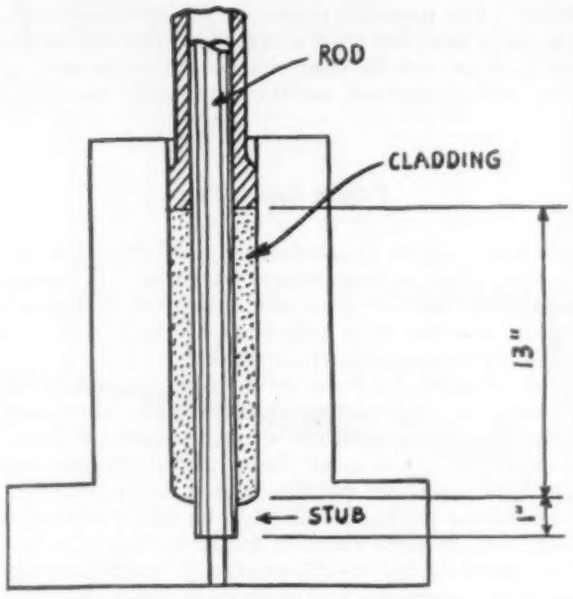



Fig. 2

the ingot iron base wire to produce a weld deposit of standard Type 307 Stainless Steel. A $^{5}/_{32}$-in. diameter base wire clad to a finished diameter of 0.249 in. ($^{1}/_{4}$ in.) will produce such an analysis. Another possibility is a $^{3}/_{32}$-in. diameter base wire clad to $^{5}/_{32}$- or $^{7}/_{64}$-in. diameter base wire clad to $^{3}/_{16}$-in. finished diameter. There are endless possibilities available in any conceivable analysis by varying the quantity of cladding to the quantity of base metal. The maximum chrome nickel content thus far achieved, without exceeding a workable finished diameter, has been the 25/20 grade of heat-resistant alloy.

Many additional standard analyses of stainless, tool steel, corrosion-resistant, hard-facing grades, etc., have been produced. Variations from the standard analysis have been obtained by varying the ratio of base material to clad material, or, which is more important, by varying the density of the cladding.

The density may be varied from 50% of drawn steel density to 85% of drawn steel density by varying the pressure exerted on the powdered metal compact around the base wire. Another method of altering the density of the cladding is to vary the quantity of filler used to fill in the voids between the powdered metal particles. This brings us to the most important item in this report, the method of producing synthetic welding rod core wire.

## Early Research

Early attempts at getting the powdered metals to adhere to the base wire and to form a smooth even case were alternately discouraging and heartening. Equipment was make-shift and to add to other difficulties few of the rules for producing normal powdered metal compacts were applicable.

Most of the first test rods were made by pressing the metal powders around short lengths of mild steel wire by the use of a steel die similar to that shown in Fig. 2 in which the base wire passed through the piston while the powders were being compressed. The results from this method of production were only fair, particularly in view of the fact that the process was slow and the yield low. It did serve, however, to lay the groundwork for determining particle-size requirements, sintering characteristics and weldability of the finished product.

It took many months of concerted effort to find that the metal powders, if properly selected for particle size and mixed with a suitable filler and bonding material, could be readily extruded much the same as welding rod fluxes are now extruded on drawn welding wire. Next, the proper filler and binder had to be found, a filler which would not alter the welding characteristics, and a binder which, if organic, would volatilize out of the compact at some point below the sintering temperature to prevent excessive carbon pickup during welding.

## Sintering

Many lubricants were tested in order to find the mixture that produced the two essential features desired, that of aiding material flow during extruding and allowing the low-temperature sintering to take effect.

The original sintering cycles were long and at relatively high temperatures, but experience showed us that thorough sintering, as considered in the manufacture of powdered metal machine parts, was not necessary, and that synthetic welding wire required just sufficient bond to give the rod strength and durability to withstand normal abuse. This brought the process down to a very economical low-temperature short cycle operation.

Oxidation of the cladding during the baking and hardening treatment required the use of controlled hydrogen atmosphere in the furnace.

Hydraulic pressures exceeding the normal pressures used in extruding welding rod coatings are necessary to extrude powdered metals with sufficient finished density to allow sintering and to prevent the flaking off of the cladding during welding. This requires the use of special dies and hydraulic presses built for pressures up to 18,000 psi. on the metallic mix, although satisfactory results have been obtained at 9000 psi. pressures.

## Flux Coatings

After welding tests were made on the first samples produced, it appeared that a special flux formula would be necessary to overcome some of the unorthodox welding characteristics of the synthetic wire. This premise was soon discounted as the finished synthetic rod approached the physical and welding characteristics of drawn steel. Numerous a.-c.-d.-c. and straight d.-c. fluxes of the lime or titanium dioxide type were tried, some titanium being dipped on the rod and some being extruded, with results indicating that the same fluxes used on drawn wire may be used on synthetic wire.

With the chromium particles clad on the outside of the basic wire, in the stainless steel grades, a tendency toward losing some of the chromium in the weld deposit due to oxidation during welding was expected. In so far as tests are able to detect, this has not exceeded the normal loss from drawn wire.

Thorough mixing of the base wire with the cladding during the actual welding has been questioned repeatedly, but constant checking of chemical analysis of various weld deposits and metallographic studies of weld metal have proved that thorough mixing is apparent.

One peculiar property which has caused comment is the fact that the magnetic rod (due to the mild steel base wire and ferroalloys) will produce a nonmagnetic austenitic weld deposit of a quality equal to a deposit made by a drawn stainless steel welding rod.

## Costs

Close quality control of powder metal analysis, particle size, mixing and formulating, and extruding pres-

sures are necessary to enable us to produce synthetic wire which will give consistent weld deposits. This extra cost of quality control is offset by the relatively low cost of producing the standard stainless steel grades of welding wire. The finished cost of synthetic welding rod core wire in sizes ranging from $^1/_4$ x 14 in. to $^5/_{32}$ in. x 14 in. varies from $^2/_3$ to $^3/_4$ of the cost of mill-rolled and drawn wire. This is wire completely processed, cut to 14 in. length and ready for flux coating.

Tolerance on finished diameters can be maintained to ±0.002 in. depending upon the shop practice for replacing worn coating dies. The base wire is, of course, cut to length before the cladding is extruded on the wire and this controls the length tolerance of the finished rod.

To illustrate the cost comparison between mill-rolled and drawn stainless wire and synthetic welding wire, a cost analysis for two sizes of wire is outlined below.

The prices given above refer to quantities of 10,000 lb.

| Costs per 100 Lb. | $^5/_{32}$ In. | $^1/_4$ In. |
|---|---|---|
| Ingot iron wire cut to length | $ 5.50 | $ 5.40 |
| Powdered metal alloys | 17.00 | 17.00 |
| Filler and binder | 1.25 | 1.25 |
| Extruding and powder handling labor | 4.00 | 2.70 |
| Heat treating | 2.00 | 1.40 |
| Quality control | 1.10 | 1.00 |
| | $30.85 | $28.75 |
| Cost of mill-drawn 19/9 wire/100 lb. | $41.00 | $33.00 |

or more. The itemized prices for the synthetic wire are not hypothetical but are the costs recorded for small productions runs, and the open market prices for such items as iron wire, powdered metal, commercial heat treating, etc.

### Future Enterprise

Any metal which is powdered can be extruded on any iron, steel, alloy or pure element base wire. Considerable research has been done on combining molybdenum and tungsten powders with nickel-chrome base wire to produce alloys for special purpose welding.

Much thought has been given lately to special alloys for strength at high temperature and such other qualities as demanded for use on turbosuperchargers, rockets, jet propulsion, etc., and since the synthetic welding wire is quickly, cheaply and readily altered as to analysis, the process herein outlined will have its place in producing welding rod for those exacting requirements.

One phase of the development of particular significance is the experience and knowledge gained in extruding powdered metal compacts with sufficient density to allow sintering after extruding.

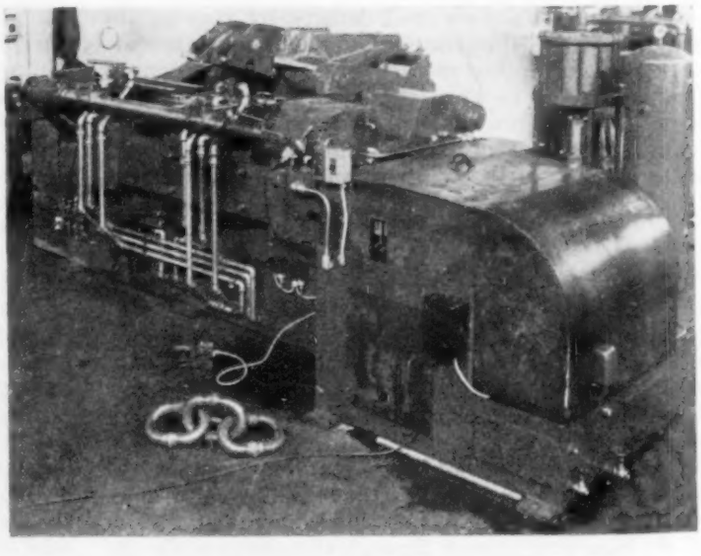
It is felt that this feature, plus the ability to clad basic metal parts with alloys, will open the door to many new applications for powder metallurgy outside of the welding electrode field.


## WE OFFER FOR IMMEDIATE DELIVERY

Extra-heavy National Mill Type Flash Butt Welder, powered by 900 KVA water-cooled welding transformer, 440 volt, 60 cycle. Movable platen actuated by two hydraulic cylinders of 12″ diameter, with feed controlled by cam-operated hydraulic unit. In excellent condition, and capable of easily welding 14 square inches in alloy steel. Complete with special welding contactor of 1800 ampere nominal rating, fully enclosed, and with low-voltage operating control.

Double-acting Hydraulic Flash-shear of sturdy design, 12″ piston diameter, with 20″ stroke.

**Location: Linden, N. J. May be seen by appointment.**



## THE MATHER SPRING COMPANY

TOLEDO, OHIO

# THE BIRD WITH THE 16-MILE TAIL

The wire you see with the parachute on the end of it is a telephone wire, being payed out from a C-47 cargo plane.

Bell Telephone Laboratories, working with the Air Technical Service Command of the Army Air Forces, developed this idea. It will save precious lives and time on the battlefield.

A soldier throws out a parachute with the wire and a weight attached. The weight drops the line to the target area. From then on, through a tube thrust out the doorway of the plane, the wire thrums out steadily — sixteen miles of it can be laid in 6 2/3 minutes. Isolated patrols can be linked quickly with headquarters. Jungles and mountain ranges no longer need be obstacles to communication.

This is in sharp contrast to the old, dangerous way. The laying of wire through swamps and over mountains often meant the transporting of coils on the backs of men crawling through jungle vegetation, and in the line of sniper fire. It is reported that in one sector of the Asiatic theater alone, 41 men were killed or wounded in a single wire-laying mission.

Bell Telephone Laboratories is handling more than 1200 development projects for the Army and the Navy. When the war is over, the Laboratories goes back to its regular job — helping the Bell System bring you the finest telephone service in the world.

**BELL TELEPHONE LABORATORIES**

**Exploring and inventing, devising and perfecting for the Armed Forces at war and for continued improvements and economies in telephone service.**

# THE AMERICAN WELDING SOCIETY

## ACTIVITIES — RELATED EVENTS

### 1945–46 OFFICERS AMERICAN WELDING SOCIETY

Since no nominations other than proposed by the Nominating Committee have been made by 25 qualified members, as prescribed by the By-Laws, the nomination ballots are treated as election ballots. Accordingly, the following have been elected officers for the year to begin on the adjournment of the 1945 Annual Meeting. These officers will be declared elected at the Business Session of the Annual Meeting.

*President*, Wendell F. Hess, Professor of Metallurgical Engineering at Rensselaer Polytechnic Institute, Troy, N. Y.

*First Vice-President*, Harold O. Hill, Asst. Chief Engineer, Fabricated Steel Construction, Bethlehem Steel Co., Bethlehem, Pa.

*Second Vice-President*, G. N. Sieger, President and General Manager, S-M-S Corp., Detroit, Mich.

*Directors at Large:* Charles H. Jennings, Section Engineer, Welding Section, Westinghouse Electric Corp., E. Pittsburgh, Pa.; A. B. Kinzel, Chief Metallurgist, Union Carbide & Carbon Res. Labs., Inc., New York, N. Y.; C. M. Underwood, Manager Welding Dept., Northern Ordnance Co., Minneapolis, Minn.; R. D. Thomas, President, Arcos Corp., Philadelphia, Pa.

*District Vice-Presidents:* District No. 1 (New York and New England)—F. W. Davis, Metallurgist, E. B. Badger & Sons Co., Boston, Mass.; District No. 2 (Mid-Eastern)—W. G. Theisinger, Asst. to Vice-Pres., Lukens Steel Co., Coatesville, Pa.; District No. 3 (Southern)—Sydney Swan, Surveyor, American Bureau of Shipping, Pascagoula, Miss.; District No. 4 (Central)—B. L. Wise, Asst. Mgr., Welder Div., Federal Machine & Welder Co., Warren, Ohio; District No. 5 (Mid-Western)—R. E. McFarland, Engineer, Western Electric Co., Inc., Chicago, Ill.; District No. 6 (Mid-Southern)—W. S. Evans, Materials Engineer, Curtiss-Wright Corp., St. Louis, Mo.; District No. 7 (Western)—C. P. Sander, Gen. Supt., Western Pipe & Steel Co. of Calif., Los Angeles, Calif.

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### VICE-PRESIDENT ELECT DIES

W. S. Evans, newly elected Vice-President for District No. 6, died July 7th after a short illness.

W. S. Evans began his aviation career with the process department of the Douglas Co. in 1938, later moving to the Northrop Co. as Assistant to the Process Engineer. He came to the St. Louis Plant of the Curtiss-Wright Airplane Division in January of 1941 to become Materials and Process Engineer and organize a department which has operated highly successfully in this plant.

He studied chemistry at the University of California at Los Angeles and took post-graduate work in chemical engineering at the University fo California at Berkeley. He was a resident of Santa Monica, Calif., before coming to St. Louis.

During the time he was with Curtiss-Wright, he had written many articles including "Arc Welding Aircraft Structures" which was published through the James F. Lincoln Arc Welding Foundation. For this article he won an award given by the Foundation. His work with Materials and Process engineers in the midwest and throughout the country was very well known. Some of the procedures that he established, especially his work with arc welding and automatic welding, have been put into use in other aircraft plants. He was personally acquainted with all Materials and Process engineers in the aircraft companies, and his death has been not only a loss to Curtiss-Wright but to the industry as a whole.

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### BOARD OF DIRECTORS MEETING

A meeting of the Board of Directors of the AMERICAN WELDING SOCIETY was held in the Engineering Societies' Bldg., New York, N. Y., June 28, 1945.

Present were: A. C. Weigel, *President*, presiding; C. A. Adams, H. C. Boardman, R. W. Clark, E. V. David, J. H. Deppeler, O. B. J. Fraser, K. L. Hansen, W. F. Hess, H. W. Lawson, J. F. Lincoln, H. W. Pierce, H. M. Priest.

Present by invitation were: H. O. Hill, *Chairman*, Technical Activities Committee; H. F. Reinhard, *Secretary*, Public Relations Committee; M. M. Kelly, *Secretary;* W. Spraragen, *Editor*, THE WELDING JOURNAL and Director, Welding Research Council; S. A. Greenberg, *Acting Technical Secretary*.

*Bereavements*

The President drew attention to the losses the SOCIETY had sustained during the past two months of its *Past-Presidents*, G. T. Horton and E. A. Doyle, and also two of its outstanding members, A. V. deForest and C. J. Holslag. Tributes to the memories of these honorable members, prepared by specially appointed committees, were read, and by a rising vote, were unanimously adopted.

*Finances*

The Treasurer presented a report covering financial operations of the SOCIETY for the past six months of the current fiscal year, commencing Oct. 1, 1944.

Membership of the AMERICAN WELDING SOCIETY, as of May 31, 1945, was reported as 8532 (140 Sustaining Members, 3245 Members, 4892 Associate Members, 234 Operating Members, 2 Honorary Members and 19 Student Members), of which only 7% are delinquent.

The Treasurer reported the SOCIETY'S financial condition, on March 31, 1945, showed a net excess of income over expense of some $20,000.

It was voted to approve recommendation of the Finance Committee for the transfer of $10,000 from the regular funds of the SOCIETY into the SOCIETY'S permanent reserve fund.

*Welding Handbook Editor*

Upon recommendation of the Welding Handbook Committee the Board of Directors authorized the employment of an editor and manager of publication of the *Welding Handbook*, whose duties, on authorization of the Board of Directors, can be expanded to include the editing and publication of other educational books than the Welding Handbook; and further, the Board of Directors vested the Welding Handbook Committee with authority to select the editor and publication manager of the Welding Handbook, at a salary within the limits recommended by the Finance Committee.

*By-Law Amendments*

On the recommendation of the By-Law Committee Chairman amendments of Article II, Section 1, Article XII and Article IX, providing for the appointment of an Honorary Membership and Honorary Directorship Committee, as shown below, were approved.

Article II

Section 1. Honorary Members—Nominations for Honorary Membership may be submitted to the Board of Directors in writing by any corporate member of the Society. Such nominations shall state the qualifications of the nominees for such membership *and shall be referred to the Honorary Membership and Honorary Directorship Committee for its recommendations.* Honorary Members shall be elected

(*Continued on page 850*)

# How MUREX FHP licked a tough job for us

Friends, did you ever know it to fail? I mean, just when your department gets running along smoothly, in marches a rush-rush job that they want done practically yesterday.

Take what happened to us last week: forty big engine bases that had to be fabricated right away, if not sooner—and each of them requiring 3860 lineal inches of welding. Tommy, our boss, took one look at the due-date on the job, and groaned.

"Okay," he said at last, trying to look cheerful. "Can do, I hope."

But after two units, we saw we'd never make it. They took 12 hours of welding time each, whereas we needed to make 10 hours or less to finish on schedule.

Whereupon I stepped up to Tommy, observing, "Look, I'm only a girl welder, and new around here anyway. But why are we using ordinary *all-purpose* electrodes on this job, when MUREX FHP would knock it off in very much less time? The last place I worked specialized in the fabrication of heavy bases and machine frames. We always used MUREX FHP on this sort of thing. Why don't we position these frames and . . ."

Tommy looked at me oddly. "Say no more, sister," he said. "Say no more. I should have seen right off the bat that this is a natural for downhand welding and good old MUREX FHP. But we were in such a rush, and I wanted to use up our stock of E6010 rods, and . . ."

The next day, a load of MUREX FHP came in. The first assembly was finished in *eight* hours as against the twelve the other rods took—*a saving of over thirty per cent!*

And, the MUREX man did us another good turn, by giving us a big new Wall Chart, which lists and classifies all of M & T's 30-odd electrodes. Now, when a new job comes in, Tommy consults the chart carefully to see which MUREX rod is the one to use...and he says we've saved lots of headaches that way.

If you have anything to do with arc-welding, you'd better send for the new Wall Chart for yourself. Just address:

**METAL & THERMIT CORPORATION**

120 BROADWAY, NEW YORK 5, N. Y.

ALBANY • CHICAGO • PITTSBURGH • SO. SAN FRANCISCO • TORONTO

**MUREX Electrodes**

by unanimous vote of the Board of Directors, except that no member of the Board of Directors shall vote upon his own admission.

Article IX

Section 8. Honorary Directors—Nominations for Honorary Directorship may be submitted to the Board of Directors in writing, by any corporate member of the Society. Such nominations shall state the qualifications of the nominee for this office *and shall be referred to the Honorary Membership and Honorary Directorship Committee for its recommendations.* Honorary Directors shall be elected by unanimous vote of the Board of Directors, except that no member of the Board of Directors shall vote upon his own admission. They shall hold office for life or until removed from office by majority vote of the Board of Directors.

Article XII

Section 13. Committee on Awards—A Committee on Awards consisting of five members each serving for a period of five years, one member retiring each year. The member senior in respect to service shall be Chairman. It shall be the duty of this Committee to make the awards and nominate those to present honorary lectures at the Annual Meeting and to arrange for the presentation of such medals, certificates or other awards as may be authorized by the Board of Directors.

*Upon authorization by the Board of Directors, the President may appoint sub-committees to this committee for stated terms to provide for the prosecution of some particular project or projects.*

Section 14. Honorary Membership and Honorary Directorship Committee. A Committee on Honorary Membership and Honorary Directorship of five members comprising the President, First Vice-President, Second Vice-President and the two latest Past-Presidents, who are living, and continuing to be members, whose duties shall be to present a statement of qualifications and make recommendations to the Board of Directors regarding all nominees presented for Honorary Membership and Honorary Directorship in the Society and to arrange for the presentation of the certificate.

Renumber Sections 14 through 22 as 15 through 23.

*Report of Public Relations Committee*

The following recommendation submitted by the Public Relations Committee was unanimously approved:

> General Recommendation on Procedure to be Followed Where Specifications, Regulations or Directives are Issued by Other Societies or Agencies That Are Considered to Be Ill-Advised, Incorrect or Otherwise Detrimental to the Best Interest of the Industry.

Where specifications, regulations or directives are issued by other societies or agencies and such are considered to be ill-advised, incorrect or otherwise detrimental to the best interests of the welding industry, the staff shall submit the particular question to the proper American Welding Society committee, with the request that such committee advise the Board of Directors as to the facts.

That the Board of Directors then determine what further action shall be taken in the matter and whether the action shall be taken by the Public Relations Committee, other committee or by the staff.

*Technical Activities Committee Recommendations*

It was voted that the Code of Minimum Requirements for Instruction of Welding Operators: Part A—Arc Welding of Steel $^{3}/_{16}$ to $^{3}/_{4}$ in. thick, be given the status of a full standard of the Society, in accordance with the recommendation of the Technical Activities Committee.

It was voted that authorization be granted the Technical Activities Committee to proceed with publication of a modified version of the *U. S. Army Ordnance Inspection Handbook for Manual Metal Arc Welding*, issued as an A.W.S. emergency standard.

*Report of Special A.W.S. Group on Filler Metal Technical Specification*

It was voted to accept the finding of the special group appointed to hear and consider the objections of J. F. Lincoln to the joint A.W.S.-A.S.T.M. Specifications for Arc Welding Electrodes, which in effect reads as follows:

> "That it is the opinion of the group that there is insufficient evidence of a necessity for any change in this specification at the present time."

Does YOUR SHOP HAVE CYLINDER-ITIS?

● Cylinder-itis is caused by excessive cylinder-handling costs . . . by interrupted welding operations . . . and by the return of cylinders which are not actually empty!

If your shop is troubled with cylinder-itis investigate the time and money-saving advantages of a modern RegO Manifold . . . there's no obligation . . . write today!

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Pioneers and Leaders in Equipment for Using and Controlling High Pressure Gases

For superior welding
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use these
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RACO 10011 E 10011
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ELECTRODES FOR POSITIONED WELDING
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RACO 10020 E 10020
Flat-Position Type
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RACO 5 E 6030
With the increasing popularity of transformer welders of all types, the demand for A.C. electrodes for welding mild steel and high-tensile, low-alloy steels is steadily mounting. The outstanding advantage of alternating current for welding is, of course, the practical elimination of magnetic arc blow. For this reason, A.C. electrodes are especially desirable in assemblies involving intricate corner welding, gapped seams, or under other conditions favoring arc blow.
All the above electrodes give excellent results when used with direct current. Samples on request.
The REID-AVERY COMPANY
INCORPORATED
DUNDALK BALTIMORE 2 MARYLAND
SINCE 1919 PRODUCERS OF ARC WELDING ELE WELDING RODS

### Proposed A.W.S. Railroad Welding Committee Recommended Scope and Personnel

It was voted that the scope and personnel of the A.W.S. Railroad Welding Committee, recommended by the Technical Activities Committee, be approved. The scope and personnel of the Committee as approved, is given below:

*Scope*

The A.W.S. Railroad Welding Committee will be concerned with the formulation of safe, sound and progressive practices in the application of welding and associated processes to the railroad industry. The Committee will bring together representatives of the railroads and car and locomotive builders for a mutual interchange of information; for the stimulation of new activities; and for the widest possible dissemination of existing welding knowledge.

*Personnel (22)*

Leland Grant (*Temporary Chairman*), Chicago, St. Paul & Milwaukee R.R., Milwaukee, Wis.

S. A. Greenberg (*Temporary Secretary*), American Welding Society, 33 West 39th St., New York 18, N. Y.

E. R. Battley, Canadian National Railways, Montreal, Quebec, Canada.

B. Bishop, Lima Locomotive Co., Lima, Ohio.

W. G. Boese, Pullman Standard Car Mfg. Co., Michigan City, Ind.

J. Cannon, Asst. Chief Eng., Mt. Vernon Car Mfg. Co., Mt. Vernon, Ill.

A. B. Chapman, Chesapeake & Ohio Railroad, Huntington, W. Va.

B. W. Covell, Northern Pacific Railway, 5th & Jackson Sts., St. Paul, Minn.

Charles Herdy, Illinois Central Railroad, Paducah, Ky.

M. A. Herzog, The St. Louis & San Francisco R.R., Springfield, Mo.

John Hengstler, The Pennsylvania Railroad, Altoona, Pa.

John Hruska, Electro-Motive Division, General Motors Corp., La Grange, Ill.

T. M. Jasper, General American Transportation Corp., 135 S. La Salle St., Chicago, Ill.

F. A. Longo, Southern Pacific Railroad, 65 Market St., San Francisco, Calif.

J. S. Miller, New York, New Haven & Hartford R.R., New Haven, Conn.

Robert Moran, Missouri Pacific Railroad, Rm. 1110 M.O.P. Bldg., St. Louis, Mo.

H. A. Patterson, Atchison, Topeka & Santa Fe R.R., 80 E. Jackson, Chicago, Ill.

A. J. Ralley, Canadian Pacific Railway Co., Montreal, Canada.

A. J. Raymo, Baldwin Locomotive Works, Philadelphia, Pa.

J. W. Sheffer, American Car & Foundry Co., 30 Church St., New York, N. Y.

A. F. Stiglmeier, New York Central Railroad, 466 Lexington Ave., New York, N. Y.

H. S. Swan, American Locomotive Co., Schenectady, N. Y.

### DR. WENDELL F. HESS HONORED

At a luncheon meeting of the American Iron and Steel Institute, George S. Rose, Secretary of the Institute, presented to Dr. Wendell F. Hess, President-Elect of the AMERICAN WELDING SOCIETY, the Institute Medal for the year 1944 for his paper, entitled "Recent Progress in the Scientific Application of Welding to Steel."

The American Iron and Steel Institute Medal was established by the Directors at their thirty-second general meeting in New York on Oct. 28, 1927, to perpetuate the memory of the late Elbert H. Gary, first President, and to stimulate improvement in the American iron and steel industry. The Medal is awarded for a paper read before the American Iron and Steel Institute having special merit and importance in connection with the activities and interest of the American iron and steel industry.

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### TECHNICAL SOCIETIES COUNCIL

Seventeen technical and professional societies of Greater Kansas City, their memberships totaling approximately 3000 highly trained persons, joined forces in the Technical Societies Council.

Formal organization by the thirty-four delegates at a dinner, July 9th, at the Hotel President was hailed as an indication of determination by researchers to


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Carbide
IN THE RED DRUM

EFFICIENT
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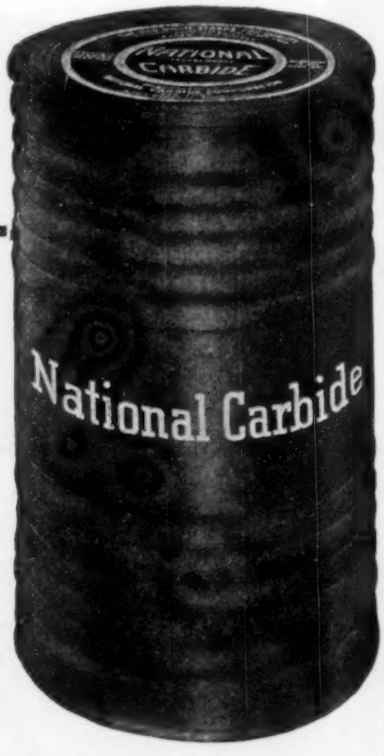


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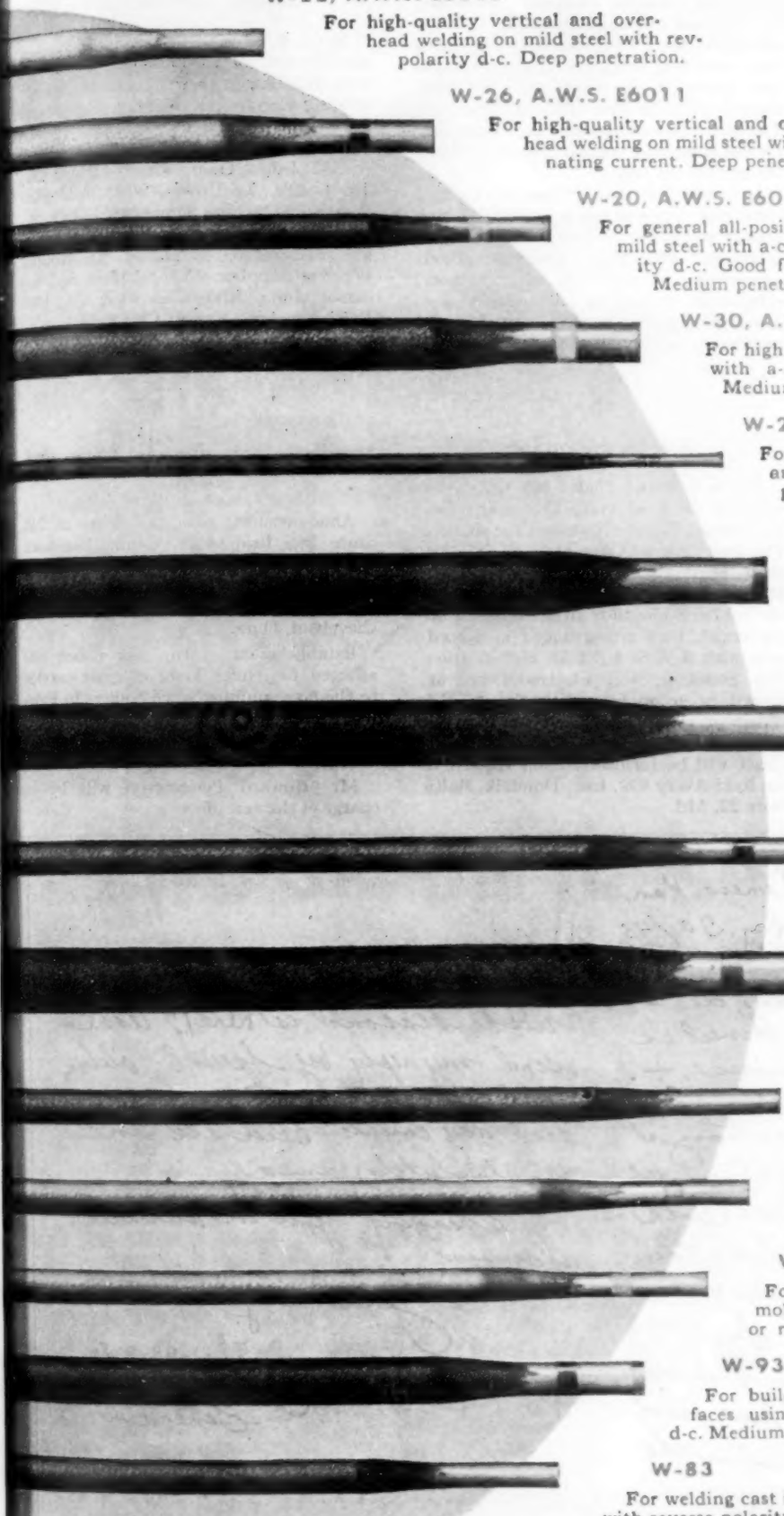
Use National Carbide in the Red Drum
60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York, N. Y.



**W-22, A.W.S. E6010**

For high-quality vertical and overhead welding on mild steel with rev-polarity d-c. Deep penetration.

**W-26, A.W.S. E6011**

For high-quality vertical and overhead welding on mild steel with alternating current. Deep penetration.

**W-20, A.W.S. E6012**

For general all-position welding on mild steel with a-c or straight-polarity d-c. Good for poor-fit-up work. Medium penetration.

**W-30, A.W.S. E6012**

For high-speed welding on mild steel with a-c or straight-polarity d-c. Medium penetration.

**W-25, A.W.S. E6013**

For welding light-gage mild steel in any position with a-c or straight-polarity d-c. Light penetration.

**W-24, A.W.S. E6020**

For welding horizontal fillets and flat joints on mild steel with a-c or straight polarity d-c. Approved for both conventional and deep-fillet techniques. Deep penetration.

**W-27, A.W.S. E6020**

For horizontal fillet welds and joints of all types in the flat position using a-c or d-c. Deep penetration.

**W-52, A.W.S. E7010**

For high-quality vertical and overhead welding on low-alloy, high-tensile steel with reverse-polarity d-c. Deep penetration.

**W-54, A.W.S. E7020**

For welding horizontal fillets and flat joints on low-alloy, high-tensile steel with a-c or straight-polarity d-c. Deep penetration.

**W-55**

For all-position welding of SAE 4130 and low-alloy, high-tensile steels using a-c or straight-polarity d-c. Medium penetration.

**W-56, A.W.S. E7011**

For high-quality vertical and overhead welding of low-alloy, high-tensile steels using a-c or reverse-polarity d-c. Deep penetration.

**W-58, A.W.S. E8011**

For high-quality welding of chrome moly steel, in all positions, using a-c or reverse-polarity d-c. Deep pen.

**W-93**

For building up wear-resisting surfaces using a-c or reverse-polarity d-c. Medium penetration.

**W-83**

For welding cast iron in any position with reverse-polarity d-c or with a-c. Medium penetration.

**NOTE: Tear this page out and fasten to wall for a ready-reference chart.**

# GENERAL ELECTRIC

BUY WAR BONDS

873-50(C)-8748

explore every opportunity for the industrial upbuilding of this region.

Dr. W. M. Hoehn, representative of the American Chemical Society and employed by George A. Breon & Co., was named chairman of the council, with C. M. Lytle of the Missouri Society of Professional Engineers and the Kansas City Power & Light Co., as vice-chairman, and Charles Briggs, American Society of Mechanical Engineers and the Burns & McDonnell Engineering Co., as secretary-treasurer. All three have been prominent in professional organizations.

## WELDING ARMY'S NEW FLOATING ALUMINUM BRIDGE

The atomic-hydrogen arc-welding process and machine welding by the new inert-arc a.-c. process without flux, both of which were developed by the General Electric Co., have been approved by the Army Engineer Board for use in the construction of the Army's lightweight, or floating aluminum, pontoon bridge. The newly designed bridge consists of a series of balks or hollow square beams of aluminum alloy, which are so light that they can be placed by hand and so strong that they will bear 50-ton loads. The beams lock together with pins and form a flooring which rests on pontoon boats.

Original specifications for the balks or beams called for automatic carbon arc welding of the longitudinal seams, two of which are required to make a box section from two extruded channels. However, as the result of samples made by G-E engineers at the Detroit plant of the Copco Steel and Engineering Co., approval has been given for the use of the atomic-hydrogen and the inert-arc a.-c. processes. The latter process has also been approved for use in making manual closure welds on the ends of the balks.

It is expected that the use of either of these processes will result in welds of high quality and better contour, made at higher speeds and at lower costs than the methods previously authorized. Furthermore, elimination of flux in the inert-arc a.-c. process is expected to save both time and money by making pickling unnecessary.

## ELECTRODE CHART

A comprehensive index has been compiled by the Reid-Avery Co. on the various arc-welding electrodes on the market. The chart covers Carbon Steel, Stainless Steel, High Tensile, Hard Surfacing and Manganese Steel Electrodes. In so far as the mild and low-alloy steel electrodes are concerned, they are arranged in accordance with A.W.S.-A.S.T.M. classification. The Stainless Steel Electrodes are arranged in accordance with the A.I.S.I. classification. The Hard Facing Electrodes are classified according to Hardness. Chart will be furnished upon request of the Reid-Avery Co., Inc., Dundalk, Baltimore 22, Md.

## MUREX DISTRIBUTORS

Metal & Thermit Corp. announces the appointment of the following companies who will handle their line of Murex arc welding electrodes: Welding Equipment & Mill Supply Co., Galion, Ohio; Industrial Gas Distributors, 1916 Vermont Ave., Toledo 2, Ohio; Randall-Ebner Co., 316 Jay St., La Crosse, Wis.; Alhambra Repair & Machine Shop, 1315—30th St., Sacramento, Calif.; Acme Welding Supply Co., Fargo, N. D.; J. D. Hopper Welding Supplies, 1500 S. Main St., Anderson, Ind.; Kirk-Wiklund & Co., 1704 Baltimore Ave., Kansas City 8, Mo.

## LINCOLN DISTRIBUTORS OPEN NEW OFFICE

Announcement of a new office at 211 State St., Bridgeport, Conn., has been made by Alfred B. King & Co., distributors of Lincoln arc welders and welding supplies for The Lincoln Electric Co., Cleveland, Ohio.

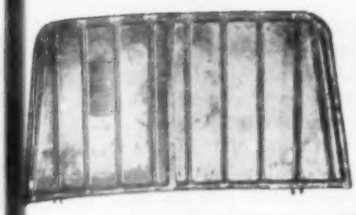
Establishment of the new Office was affected to render more efficient service to the large number of customers in Fairfield County, according to officials of A. B. King & Co., whose main office is located at New Haven.

Mr. Howard Pennington will be in charge of the new office.

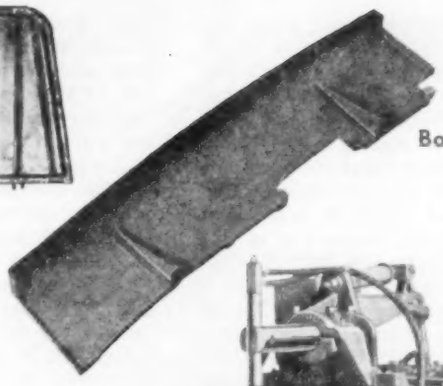

Seneca, Kan.
May. 30, /45

Gentlemen;
I am a recently dis-
charged veteran. I served in
Australia, New Guinea, &
Netherlands East Indies. In
all three of these locations I
have used your Sight-Feed
Acetylene Generators. Both
25 + 100 lb. sizes. I like them.
Dad is buying one for
our shop. I want a Sight-
Feed in that shop. I know
how safe they are. I have used
them in civilization and in the
jungle; they are very safe
Please quote me your
prices on your 12 lb. + 25 lb.
sizes of Generators We are in
urgent need of one as the
rush season is here Please
send my reply by Special-delivery.
I have no time to waste, as
each day counts. Our old one
is absolutely unsafe.
Thanking you in advance
I remain
Yours truly
John J. Adam
Seneca
Kansas

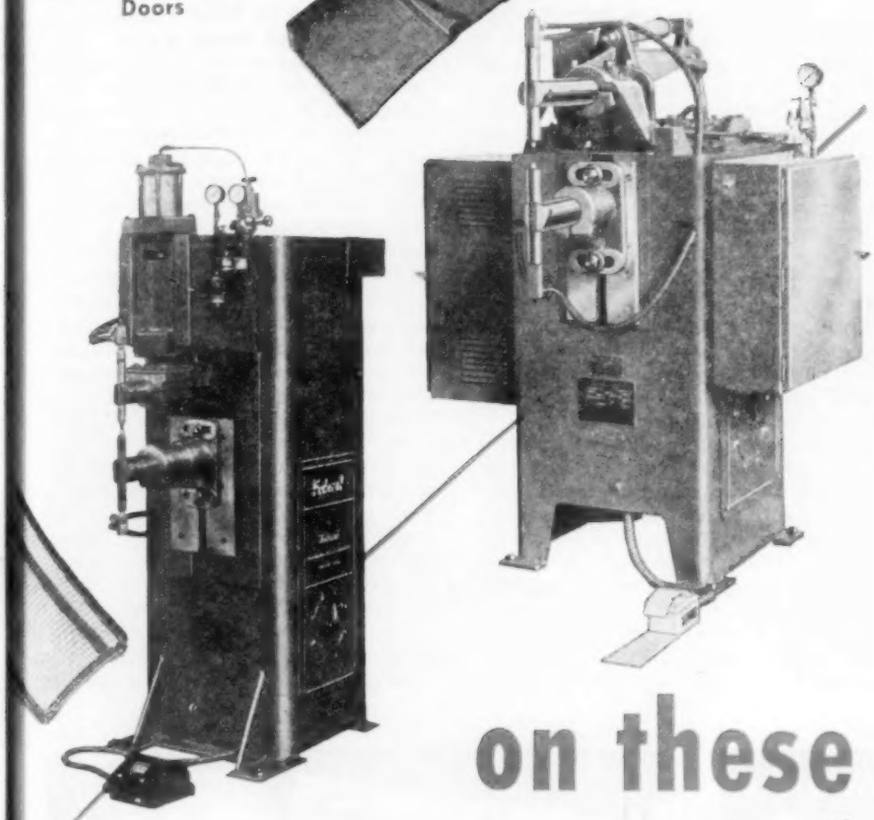
THE SIGHT FEED GENERATOR CO.
Richmond, Indiana



Cabinets and Doors



Body Panels



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## Let us tell you How

MEMBER RESISTANCE WELDER MANUFACTURERS ASSOCIATION RWMA

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WARREN, OHIO

# VERSATILE MODERN PRODUCTION TOOLS

## READY-TO-NAIL MOULDINGS

Decorative or utility type metal mouldings with steel brads permanently attached, ready for continuous nailing, are made on a high production basis with the aid of automatic resistance welding employing a press type welder developed by The Federal Machine and Welder Company. The moulding is automatically indexed for proper spacing and the brads automatically cut and fed from wire reels. They go on in a hurry, and they never come off. The process is adaptable to many sizes of moulding and brads or nails.

## "SELF-FASTENED" FABRICATIONS

Heavy duty metal tool and tackle boxes are made in the modern manner without the aid of any fasteners other than weld nuggets of the fabricated metal. One manufacturer has devised a lid-locking box in which not only is the box itself completely resistance welded, but hinges, handles and even the removable tray are made without fastenings. Using Federal spot welders with variable electrodes, this method can be made highly flexible . . . profitable on small runs of a variety of sizes and styles of containers. Such welders, operated according to instructions, make fabrications that are well nigh indestructible . . . neat and modern in appearance.

## USEFUL SPOT WELDER BOOK

Detailed descriptions of a complete line of rocker-arm type spot welders made by The Federal Machine and Welder Company, plus some interesting discussion of the type of work to which they are best suited, are included in a new book offered by this company. Designated as "Bulletin No. 4510", it contains helpful information on air-operated, motor-operated and foot-operated spot welders.

The new book gives a clear idea of what a rocker-arm spot welder is and what it can do. It combines data formerly available in a group of separate folders, and is designed to simplify the problem of selecting the type of spot welding equipment best suited to particular production set-ups. Free copies may be had on request.

## AMERICAN BUREAU OF SHIPPING MEETING

The Semi-Annual Meeting of the Board of Managers of the American Bureau of Shipping was held July 31st in the boardroom of the Bureau at 47 Beaver St., New York City.

President J. Lewis Luckenbach presided, and in his remarks stated:

"Production of large merchant types of seagoing vessels over 2000 gross tons by American shipyards during the first six months of 1945 reflects the current tapering off of the war emergency shipbuilding program. While the results achieved during the past half year have been very commendable, they cannot compare with the tremendous production during the last six months of 1943, when the peak in merchant vessel construction was reached. However, more than three vessels per day have been finished so far this year. Completion of merchant vessels during the last half of this year will taper off still further, but gradually, so that on Jan. 1, 1946, there will remain to be completed for the Maritime Commission about 58 vessels of 500,000 gross tons and 750,000 deadweight tons, plus a few for the Dutch government, and whatever new contracts develop in the interim. About 617 large merchant vessels of 4,175,170 gross tons now remain to be completed for the Maritime Commission and other interests, plus more than 550 small vessels.

"Between Jan. 1st and June 30th, American shipyards completed 674 large merchant vessels of 5,037,639 gross tons and 6,825,106 deadweight tons. The horsepower of the propulsion machinery installed in these vessels totals 3,917,960, which includes 164,900 horsepower of internal combustion engines. This brings the total production through the war years, 1939 to date, up to 4709 vessels of 35,838,764 gross tons and 51,496,746 deadweight tons, with 20,903,948 horsepower of propelling machinery, of which 757,618 horsepower was Diesel power. This is truly a remarkable and unparalleled achievement by the shipbuilding industry of the United States, an industry which but ten to twelve years ago, during the depression, only constructed five or six big ships per year. It has been clearly demonstrated that the industry retained the know-how and also a nucleus upon which expansion could be built.

"The total production of merchant vessels over 2000 gross tons by American shipyards during the war years is equal to more than one-half of the number and two-thirds of the gross and deadweight tonnage which existed throughout the world in 1939 before the start of hostilities. It is twice as large in number and two and one-half times in tonnage as the prewar British Empire ocean-going merchant fleet.

"Merchant vessels over 2000 gross tons completed during the first six months of 1945 include 110 tankers and 564 cargo vessels and transports. The 110 tank vessels have a deadweight of 1,787,921 tons, and all but three are of the large ocean-going type. Turbo-electric propelling machinery is installed in 102 of these vessels. The 564 cargo and transport type vessels have a deadweight of 5,037,185 tons, and included in this total are 97 of the Cl-M Diesel propelled cargo vessels. Included also are 225 Victory ships, making a grand total of this type to date of 434 of 4,521,387 deadweight tons.

"The emergency Liberty ship building program was recently completed, except for 12 of 24 vessels which are being built as colliers and 24 which will be used for the transport of boxed aircraft. Up to July 1st a total of 2682 Liberty ships had been completed by 18 shipyards, including 62 vessels finished as tankers and 12 as colliers. The 2608 Liberty cargo ships were built in an average time of 61.8 days each, with a good many being turned out in 28 and 30 days at some of the yards. The Liberty ship fleet, including all types, has a deadweight carrying capacity of 28,477,437 tons—a tonnage which is greater than the entire prewar deadweight tonnage of the British Empire ocean-going merchant fleet, which then totaled 22,133,400 tons. The Liberty ship fleet equals in tonnage the entire prewar ocean-going fleets of Japan, Norway, Germany, Italy, Netherlands, France and Greece. In fact, the Liberty tonnage is equal to more than one-third of the tonnage existing in the world before the war commenced in 1939, which was 72,859,400 tons.

"Tanker building for the past six months has continued at the rate of about 200 per year, the rate at which they were built during 1943 and 1944, so that American shipyards have completed since Sept. 1939, a total of 689 of 6,837,117 gross tons,

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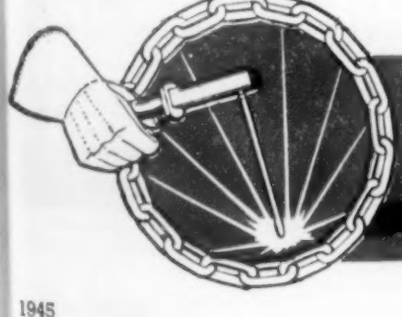
THE advantages of McKay *Stainless* Welding Electrodes are now made available to AC equipment users by the addition of an AC series to the popular McKay *certified* and *researched* line.

These new AC electrodes, conforming to A.I.S.I. specifications and type numbers, have a special titania coating (cream in color) and similar operating characteristics to their corresponding stainless types for DC Reverse or DC-AC operating. Available in 25 or 50 lb. cartons.

Full information is obtainable from your nearest McKay representative or distributor. Your inquiries are invited. When ordering be sure to specify—AC Type.

### AVAILABLE IN THESE GRADES

- Type No. 308
- Type No. 309
- Type No. 309 Cb
- Type No. 310
- Type No. 316
- Type No. 347
- Type No. 410
- Type No. 430
- Type No. 502



GENERAL SALES OFFICES: YORK, PA.

THE McKAY COMPANY
PITTSBURGH, PA.

WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

10,873,860 deadweight tons and 4,942,580 horsepower. About 112 American flag tankers of 1,425,000 dead-weight tons have been lost during the war. In Sept. 1939, there were 366 ocean-going tankers over 2000 gross tons each, of 4,282,100 deadweight tons registered under the American flag. We now have 858 tankers of 13,150,000 deadweight tons, or about 65% of the world tanker tonnage now in existence. An additional 76 tankers of 820,500 deadweight tons are owned by American interests but registered under the flag of Panama and other nations. Another 68 large tankers of 1,000,000 deadweight tons remain to be built before the end of this year. Although about 600 United Nations tankers of 6,800,000 deadweight tons have been lost during the war from a prewar world total of 1507 of 16,008,300 deadweight tons, there is now in existence a greater number and tonnage of world-owned tank ships than ever existed before. This type of vessel now totals about 1580 of 20,200,000 deadweight tons—an increase of 4,000,000 tons over the prewar fleet. With a 25% increase in the average speed of the American tanker fleet, there is an apparent additional increase of 3,000,000 deadweight tons.

"Prospects for new shipbuilding in the future on a more normal basis are fair. A number of designs have been prepared contemplating the construction of special types of vessels to replace the many that have been lost during the war or radically converted for military use. Some of these new shipbuilding proposals should materialize in time to provide work for shipyards before the end of the war-emergency shipbuilding program.

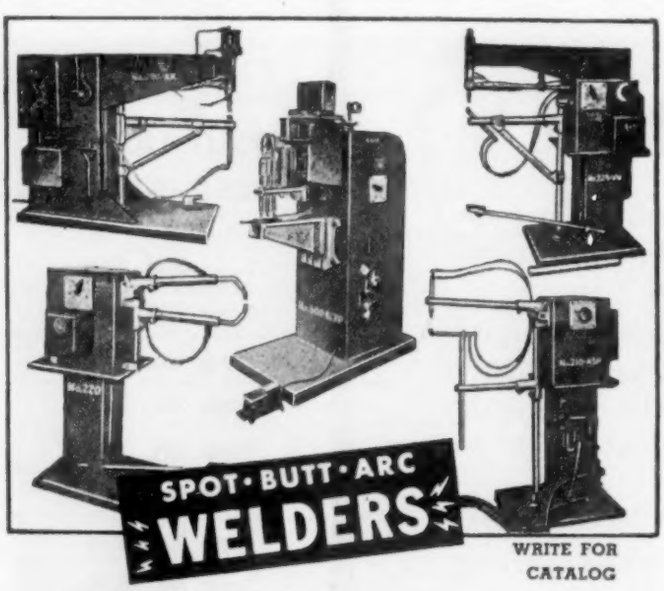
"Of the ships now under construction, a total of 88 of 775,000 gross tons and 1,000,000 deadweight tons have been contracted to be purchased by American shipping companies. All of these are included in the present Maritime Commission program. The nucleus of the new American merchant marine is thus being formed, with ship owners replacing old and lost tonnage with modern economical vessels. The prospects are that in the international trades American ship owners will resume operations with practically all new tonnage.

"Structural difficulties in welded ships continue to decline in number. The experience gained by research work that has been carried on not only in this country but abroad, and with which this Bureau is familiar, undoubtedly has had a beneficial effect. There is no question but that welding is definitely here to stay. I might mention that the new tanker SS *Phoenix* and the new ore carrier, SS *Venore*, are both most noteworthy vessels, each excelling but in different factors. The *Phoenix* is the largest all-welded vessel in the world and the *Venore*, while welded to a large degree is not completely welded, and has the most modern machinery installation with pressures hitherto untried on shipboard, which I have previously described.

"If we looked at alone from the unemployment status which we may expect following the cessation of hostilities, it would seem that it would be our duty to keep as many ships as possible on the high seas. Millions of dollars have been spent and many thousands of men trained in the running and navigation of ships and their machinery. It is our duty to see that they get jobs in a profession for which we have equipped them. The more ships and men we have visiting the ports of the world, the more we can sell to these nations and the more we can buy.

"We speak of a going fleet and a laid-up reserve fleet of sufficient size, which is so necessary to our national security. The greater the fleet that will be kept in operation and not laid up, the more men trained and engaged in their operation, the better our national security. The keeping of ships in operation not only affords employment to the personnel on shipboard but also to the shipyard and repair plants which have built up their facilities and where a large number of skilled workers in the profession of shipbuilding and repair have been gained. We should use extreme care before we scrap too much of an industry which has been built up at such tremendous expense, both in time and dollars, and human endeavor, and which we may need again. The best way to do this is to find re-employment for our ships under peace conditions so we can really have that security which we all want and for which we have been fighting this war.

"Ships in themselves are of no value. We found that out. It is the ship with the personnel schooled in its operation that is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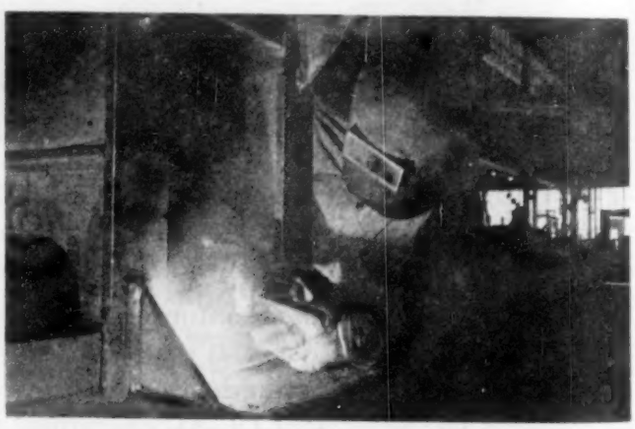

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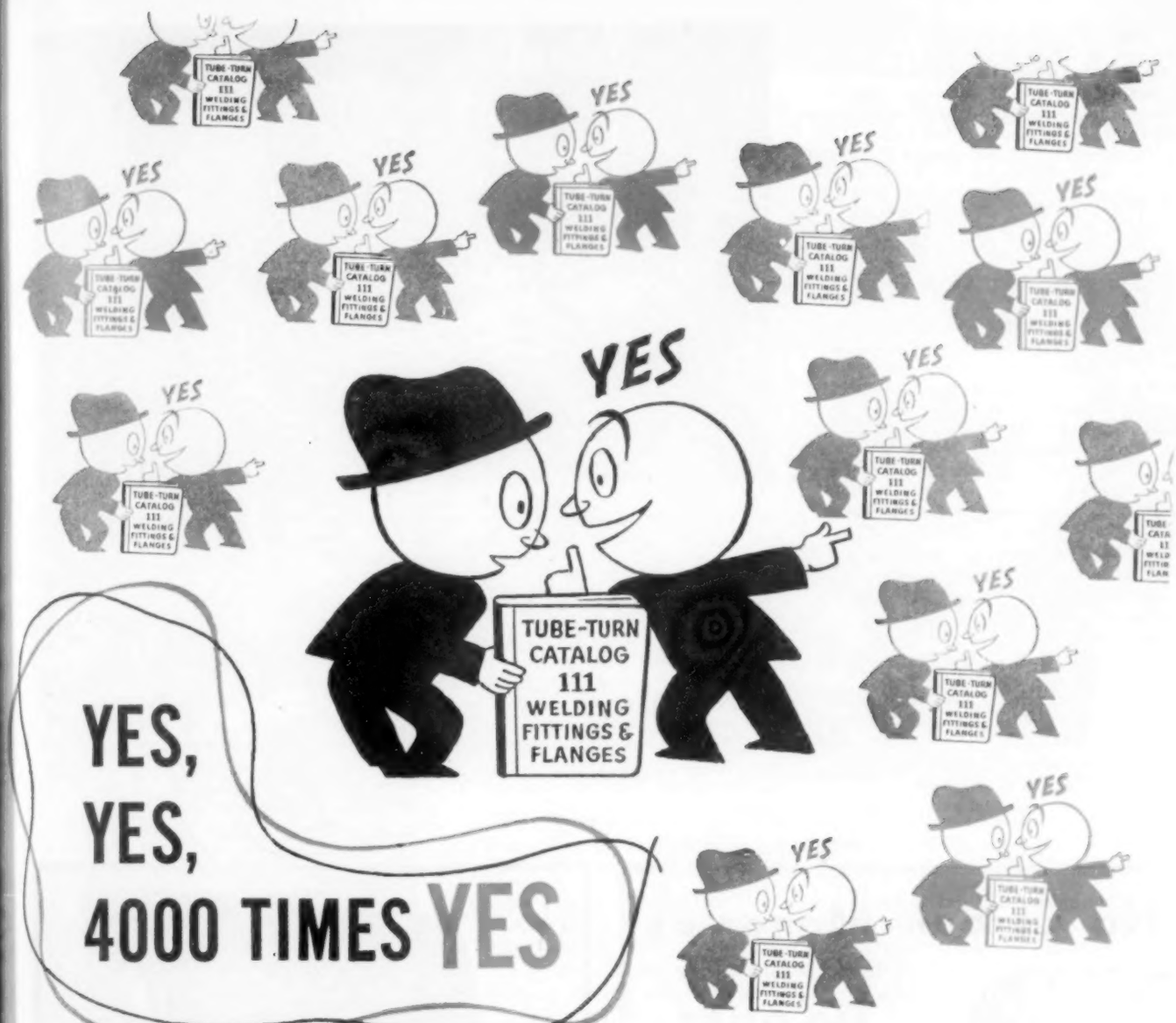
SINCE 1913

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ARMY (E) NAVY M

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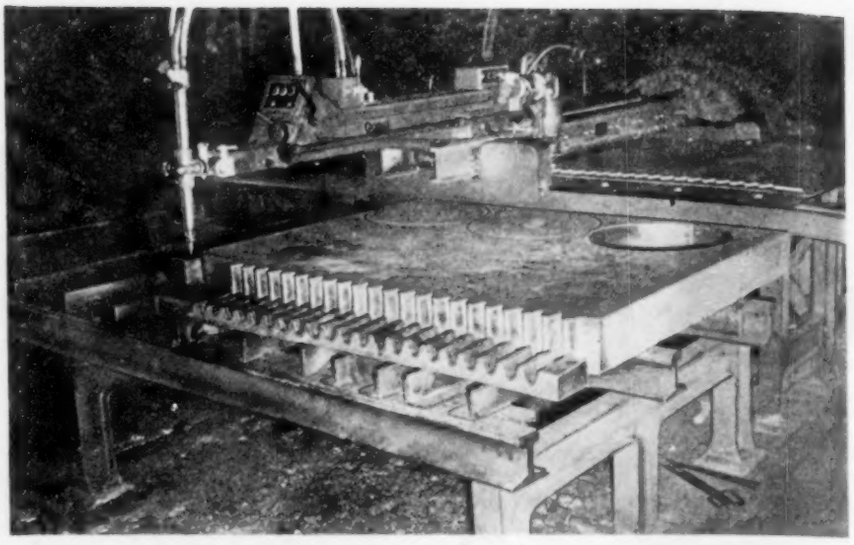
the valuable unit. A ship in itself is a menace if the personnel on board that ship are not skilled in its operation. This is particularly true in war when many of the aids to navigation used in peacetime are blacked out because of hostilities. Let us think twice before we scrap—lay up—and dispose of to others—too much of our tonnage."

## FLAME-CUT CINDER CAR RACK

By using an oxyacetylene shape-cutting machine, a midwestern steel plant recently saved more than 50% of the cost of a new piece of equipment. This plant needed a replacement for a cinder car rack, a structure 5 ft. x 4 in. x $2^1/_4$ in., used to hold the cinder car while it is being tipped to discharge its molten slag. The original rack had been cast. To avoid the high cost and lengthy delay that would be involved in making a pattern and mold for the single replacement, it was decided to flame-cut the part from a 5-in. thick steel slab with an Oxweld CM-12 shape-cutting machine.

Since only a limited number of the racks were to be cut, a templet for guiding the cutting machine was sawed out of $^1/_4$-in. composition board instead of using the standard aluminum templet strip. This faster, cheaper method was entirely satisfactory for this application because the templet was used only a few times.

Total cost for material and cutting for each rack was estimated at $18.30 as compared with $40, the estimated cost of a new cast part. Flame cutting was sufficiently accurate so that no machining of the part was necessary. A further saving is realized by this steel plant since it is now unnecessary to stock these racks as replacements or wait for delivery when needed.



The Oxweld CM-12 Cutting Machine and the Completed Rack. Notice That a Pair of Racks Are Made with Each Single Cut. Gear Blanks Have Been Cut from Part of the Slab, Using the Same Machine

## PRACTICAL DESIGN FOR ARC WELDING—VOL. 3

*Practical Design for Arc Welding—Vol. 3*, by Robert E. Kinkead, published by The Hobart Brothers Company, Troy, Ohio. Cloth Bound, $8^1/_2$ x 11", 200 pages. Price per volume $3.50; 3-volume set, Vols. 1, 2, 3, $10.00.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# Enclosed CLARE *"Custom-Built"* RELAYS

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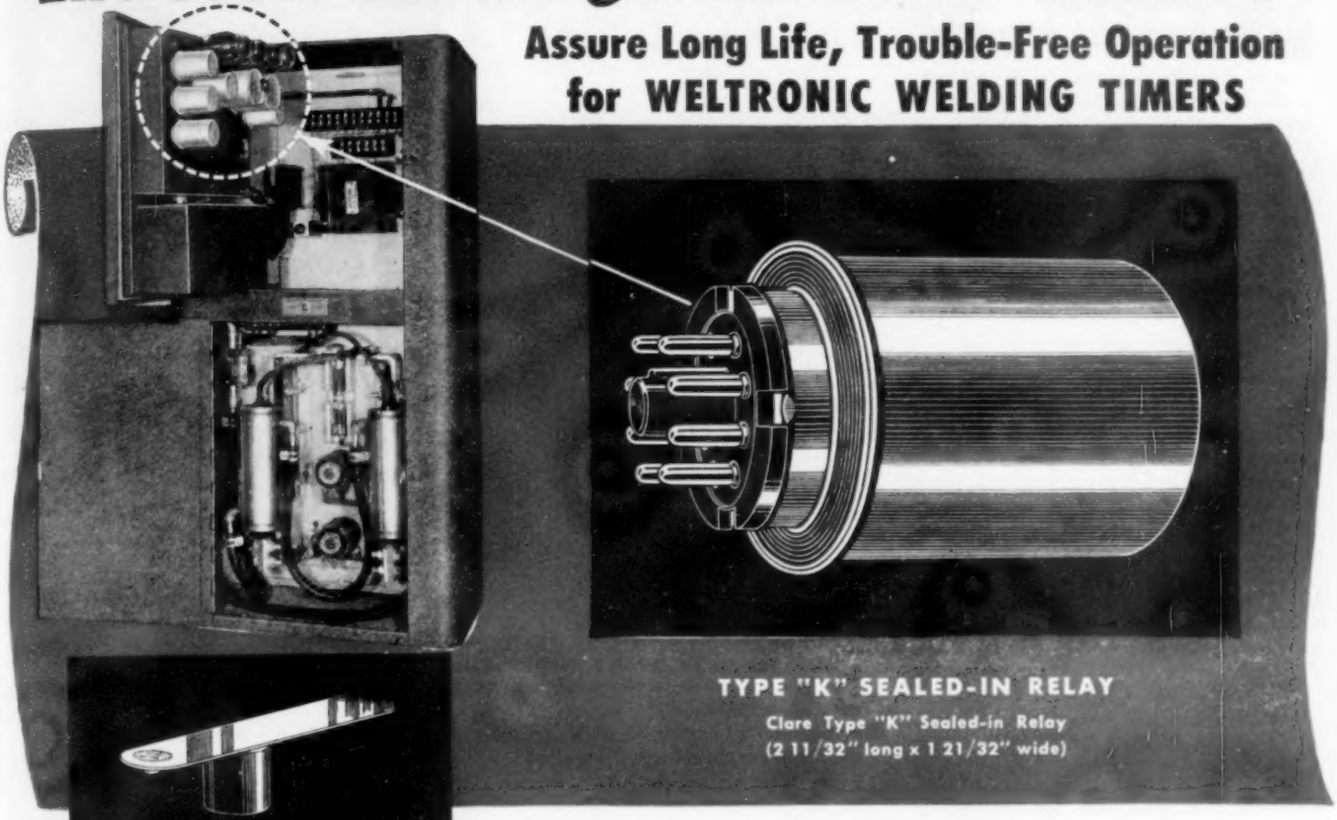


TYPE "K" SEALED-IN RELAY

Clare Type "K" Sealed-in Relay
(2 11/32" long x 1 21/32" wide)



Strong, hard, long wearing Bakelite bushing insulators resist vibration and heavy contact pressures.

Hinge of "fatigueless" beryllium copper insures long life under vibration.

Contacts are welded to nickel silver springs by special process.

Spring assemblies may include any combination of these basic forms.

● Welding timers have to stand the gaff. They are an important part of the production line which cannot lag from failure of individual units.

That's why the Weltronic Company of Detroit, Michigan, chose Clare Enclosed "Custom-Built" Relays as important components of their automatic weld and sequence timers. These trouble-free units are sealed against dirt and dust. The plug-in feature makes them as easy to service and replace as an electronic tube.

Five Clare Type "K" Sealed Relays, in individual protective housings, are located on the hinged control panel of the Weltronic Weld Timer illustrated above. These small, compact, fast-operating relays provide accurate timing for each operation in the welding cycle.

Clare "Custom-Built" Relays give maximum reliability in such special functions because of the flexibility of Clare design which offers a relay that will give exceptional service, long life, and absolute dependability for the specific requirement.

Exceptional performance is being provided by Clare "Custom-Built" Relays for sequence control of machine tools, counting equipment, electric eye controls, in radio, radar, and many other electronic devices. Designers and engineers should know about Clare Relays. Send for the Clare catalog and data book. Address: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 11, Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

# CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical, Electronic and Industrial Use

In this third and final volume of the Hobart welding design series, in addition to more of the "idea stimulators" that have been presented in the first two volumes, Mr. Kinkead has developed three different lines of thought that will be of particular interest to welding designers and fabricators.

Twenty design plates show in graphic form valuable hints on what *not* to do in designing for Arc Welding. These plates show common faults in design—with suggestions as to how they may be avoided.

In another twenty plates, Mr. Kinkead suggests the natural origin of many complex, modern design principles. In fact these pages might appropriately bear the title, "Romance of Design." If you take your designing seriously, you'll enjoy these pages thoroughly.

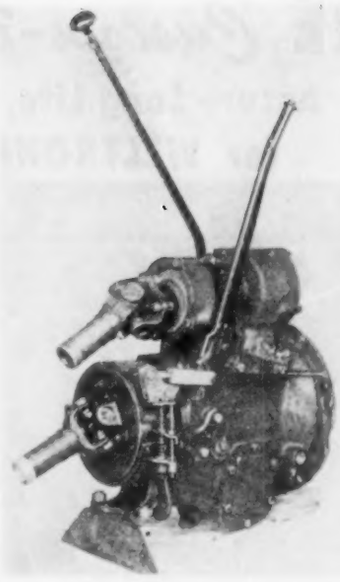
The final twenty plates show typical patents that have been granted in connection with the welding process, suggesting that the designer and fabricator of welded parts may be able to originate new methods that can be protected by patents.

Volumes 1 and 2 or "Practical Design for Arc Welding" are still available at $3.50 each; the 3-volume set being specially priced at $10.00.

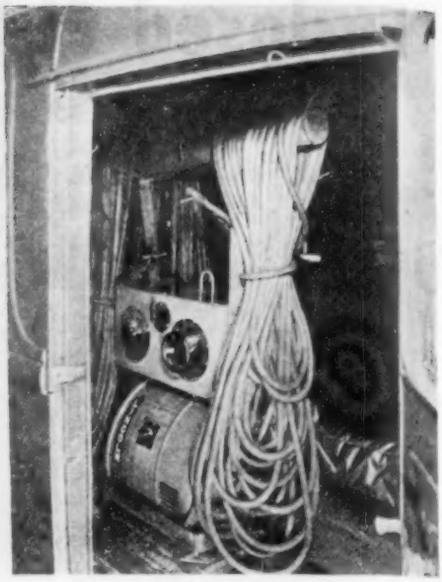
---

## NEW POWER TAKE-OFF

An idea in a power take-off direct-connected to a truck motor and eliminating the conventional V-belt drive, comprises one of the most compact setups of this kind and permits a more convenient and efficient means for making readily available various power applications wherever they are required.



New Power Take-off Unit for Truck Motor



One Application of Power Take-off for Driving Welder Generator Shown Here Mounted in Truck Body

The accompanying views show one use for this portable power arrangement whereby it is used to drive the generator for an arc-welding outfit supplied by The Lincoln Electric Co., Cleveland, Ohio.

The power take-off, designed and built by A. Tangen, 3269 Hogarth, Detroit, Mich., can quickly be installed in any Ford or Dodge truck as a permanent setup, although it can easily be removed or reinstalled in a few minutes. Built as a unit, the driving mechanism fits directly over the standard transmission case of the truck and does not interfere in any way with the normal use of the truck.

This is said to be a very economical and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| | |
|---|---|
| QUALIFICATIONS: | good knowledge of resistance welding machines and electronic control. Fair education and good personality required. |
| JOB DESCRIPTION: | setting up and testing the machines in our plant; general service work in the field. Must be able to travel as conditions require. |
| WORKING CONDITIONS: | clean modern shop; sincere, considerate supervision. High caliber fellow workers. |
| OPPORTUNITIES: | limited only by your aggressiveness and productivity. Our key men and future salesmen chosen from this group. |
| OUR COMPANY: | young enough to be aggressive, old enough to be well-established. No reconversion problem. Our profit-sharing plan, group insurance, bonus system plus the fact that our workers themselves are stockholders, makes this company a recognized leader in employer-employee relationship. |

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A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4 for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

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Fort Wayne, Indiana

# Electrodes, Wires, Fluxes

## *for welding* MONEL · NICKEL · INCONEL

***including the recently announced "132" A.C.-D.C. Rod for welding* INCONEL *and Inco "2" Gas Welding Flux for oxy-acetylene welding of alloys containing chromium***

**MONEL**

| | | |
|---|---|---|
| Oxy-Acetylene | "40" Monel Gas Welding Wire | For welding Monel, using INCO "1" Gas Welding and Brazing Flux |
| Oxy-Acetylene | "43" Monel Gas Welding Wire | For welding heavy sections of Monel for acid pickling service — no flux required |
| Metal-Arc | "130X" Monel Welding Electrode D.C. | For welding Monel; and Monel or Nickel to steel Nickel to steel |
| Submerged Melt. | "50" Monel Wire | For welding Monel |

**NICKEL**

| | | |
|---|---|---|
| Oxy-Acetylene | "41" Nickel Gas Welding Wire | For welding of pure Nickel — no flux required |
| Metal-Arc | "131" Nickel Welding Electrode D.C. | For welding pure Nickel |
| Submerged Melt. | "51" Nickel Wire | For welding pure Nickel |

**INCONEL**

| | | |
|---|---|---|
| Oxy-Acetylene | "42" Inconel Gas Welding Wire | For welding Inconel, using INCO "2" Gas Welding Flux |
| Metal-Arc | "132" Inconel Welding Electrode A.C.-D.C. | For welding Inconel |
| Submerged Melt. | "52" Inconel Wire | For welding Inconel |

**70/30 COPPER-NICKEL**

| | | |
|---|---|---|
| Oxy-Acetylene | "47" 70/30 Copper-Nickel Gas Welding Wire | For welding 70/30 Copper-Nickel using INCO "1" Gas Welding and Brazing Flux |
| Metal-Arc | "137" 70/30 Copper-Nickel Welding Electrode D.C. | For welding 70/30 Copper-Nickel |
| Submerged Melt. | "57" 70/30 Copper-Nickel Wire | For welding 70/30 Copper-Nickel |

**"K" MONEL**

| | | |
|---|---|---|
| Oxy-Acetylene | "44" "K" Monel Gas Welding Wire | For welding "K" Monel, using 2 parts INCO "2" Gas Welding Flux and 1 part Lithium Fluoride |
| Metal-Arc | "134" "K" Monel Welding Electrode D.C. | For welding "K" Monel |

**"L" NICKEL**

| | | |
|---|---|---|
| Metal-Arc | "136" Nickel Welding Electrode D.C. | For welding "L" Nickel |

**LUKENS**

**NICKEL-CLAD STEEL**

| | | |
|---|---|---|
| Metal-Arc | "131" Nickel Welding Electrode D.C. | For welding Nickel side only |

**"L" NICKEL-CLAD STEEL**

| | | |
|---|---|---|
| Metal-Arc | "136" Nickel Welding Electrode D.C. | For welding "L" Nickel side only |

**MONEL-CLAD STEEL**

| | | |
|---|---|---|
| Metal-Arc | "130X" Monel Welding Electrode D.C. | For welding Monel side only |

**INCONEL-CLAD STEEL**

| | | |
|---|---|---|
| Metal-Arc | "133" 80/20 Nickel-Chromium Welding Electrode A.C.-D.C. | For welding Inconel side only |

**FLUXES**

**INCO "1" Gas Welding and Brazing Flux** — For the welding and brazing of Monel and other nickel-copper alloys; copper and copper-nickel.

**INCO "2" Gas Welding Flux** — For the welding of all stainless steels, rustless irons, Inconel and other chromium-containing alloys.

For additional information or assistance on welding Inco Nickel Alloys, address Technical Service, The International Nickel Company

**NICKEL ALLOYS**

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall St., New York 5, N.Y.

convenient method for supply generator power from the truck motor without the use of belts. Power is transmitted direct from the motor, thus the speed of the generator is the same as that of the motor. This has been found entirely satisfactory although the speeds could be varied if necessary under special gear ratios. The governor, which can be cut in or out quickly, is connected with the power take-off.

In the installation illustrated the welder generator and supplemental equipment are compactly positioned in the truck immediately behind the cab.

The outfit is available as a kit with complete instruction for mounting, or it can be installed in the truck by the manufacturers.

## AMPCO ISSUES WELDING TECHNIQUE BULLETIN

Ampco-Trode Welding Technique, a bulletin describing methods of welding with Ampco-Trode coated aluminum bronze weldrod, has just been released by Ampco Metal, Inc., Milwaukee 4, Wisconsin. This is a letterhead size edition containing a "Weldability Chart for Copper-base Alloys" that shows the range of metals that can be successfully welded with Ampco-Trode. Copies of the bulletin will be sent free on request.

## UNDERWATER WELDING PHOTOED

The practicability of welding and cutting under water has been proved successful by a number of recent applications, such as salvage work on damaged war vessels. However, such work has literally been "done in the dark" as no one except the diver or a companion has been able to see the actual operation of this modern technical development of the arc-welding process. Now, for the first time, so far as known, underwater welding has been successfully pictured.

Shown in the upper dramatic view, Mr. R. L. E. Cook, Welding Engineer for Armco International Corp. and representing The Lincoln Electric Co., Cleveland, Ohio, is clearly seen arc welding under 15 ft. of water. The welding is being done with a mild steel electrode having a special coating that is impervious to water.

The photo was taken through a porthole in the specially designed tank used for training welders in underwater welding and cutting operations in the Mechanical Division of The Panama Canal Zone.

In the lower view, Mr. Cook is shown holding a test plate of sample weldments made under water. Shown from left to right are W. Badders, master diver and one of the principal figures in the rescue of crew members of the submarine "Squalus;"

R. L. E. Cook, welder-diver shown in the top photo; Captain W. A. Swanson, and J. R. Morgan. G. E. Fleager in diving gear is seen partially submerged at lower right. All except Mr. Cook are employed in the Mechanical Division of The Panama Canal Zone Authority.

If further information is desired, R. L. E. Cook can be reached care of Armco International Corp., Middletown, Ohio.

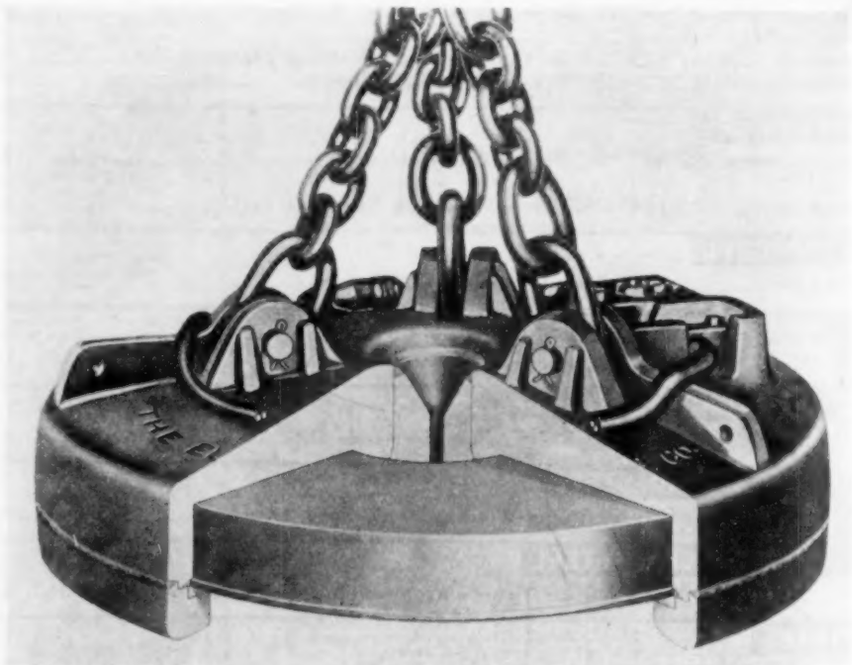
## ALL-WELDED CIRCULAR LIFTING MAGNET

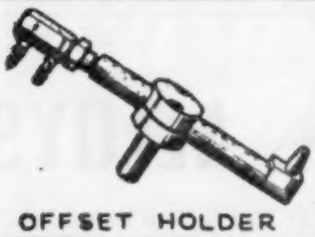
For general lifting magnet service, handling pig and scrap iron, slabs, castings and similar materials, The Electric Controller & Mfg. Co. of Cleveland, Ohio, announce the Type SW All-welded Lifting Magnet.

Radically different from previous construction, the Type SW has its coil enclosed and hermetically sealed by continuous welds in a metal case. In the accompanying illustration, the magnet-housing has been cut away to show how this metal-encased coil is welded into the housing to provide a double seal against the entrance of moisture. Welds are continuous along the inner and outer circumferences of the coil-case and magnet-housing.

Inner and outer pole shoes are also welded in place to form a streamlined magnet with straight sides. There is no overhang to catch on sides of railroad cars and the elimination of recesses in the side of the magnet for bolt heads permits a magnet of full diameter throughout its depth. This allows wider interior space, permitting a coil of greater diameter.

The coil case after welding, is vacuum treated and filled with a new (No. 282) compound which is then baked until it polymerizes to a stable condition. This new thermosetting compound is resilient and coilings to metal, has high dielectric strength, will not melt under heat (making it very desirable when handling hot materials) and will not become brittle.



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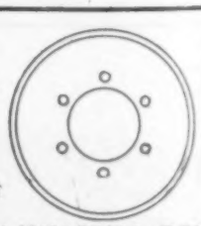
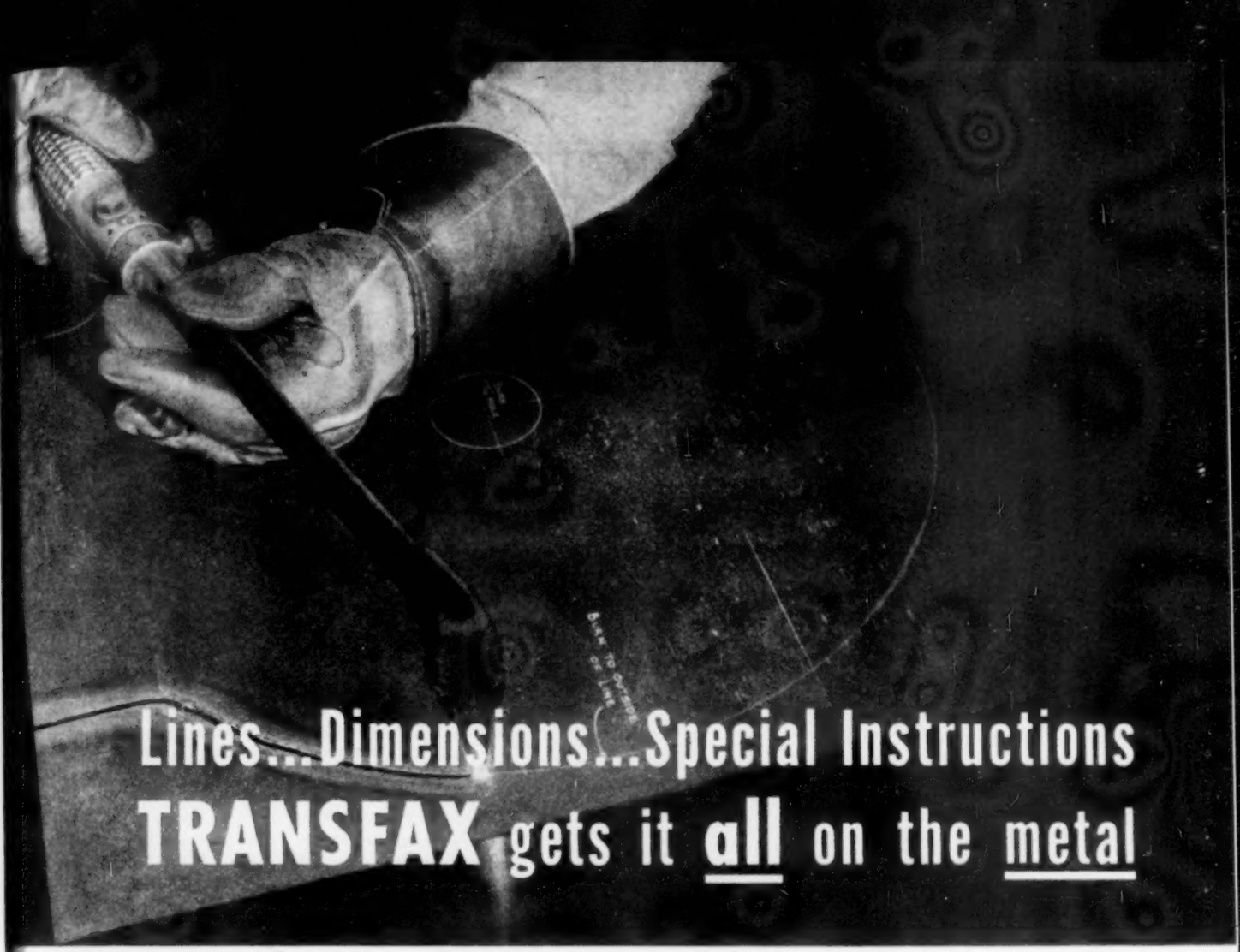


OFFSET HOLDER

THE ELECTROLOY CO. INC. 1600 SEAVIEW AVE. BRIDGEPORT, CONN. WELDING ROLL




## New reproduction process speeds today's output of welded components

You have a job to do . . . a quantity of pieces to weld—or to cut—which must fit others "on the nose" at final assembly . . .

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3—Rinse with weak ammonia solution, then with water . . . the drawing is on the metal . . .

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## KODAK TRANSFAX PROCESS

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# NEW PRODUCTS

**The Society assumes no responsibility for the validity of claims in this Section**

## INCONEL WELDING ELECTRODE

Production of a new Inconel welding electrode, suitable for both a.-c. and d.-c. welding of wrought Inconel, cast Inconel and the Inconel side of Inconel-clad steel, has been announced by The International Nickel Co.

The new rod is now in production at the company's Bayonne Works and is regarded by engineers as a long step forward in the development of welding electrodes for use with both alternating and direct current.

The new electrode is of particular importance for welding of Inconel in such fields as chemical and aviation industries, as well as in the general metallurgical fields.

Characterized by improved arcing qualities, simplicity of slag removal and an ability to make crack-free welds in any thickness, this electrode may be used on either straight or reversed polarity with d.-c. motor generator sets.

Recommended amperages for the new Inconel welding electrode, based upon electrode diameter, are indicated in the following table prepared by the Development and Research Division of The International Nickel Co.:

| Electrode Diameter | Recommended Amperages | |
|---|---|---|
| | A. C. | D. C. |
| 0.075 in. | 40–50 | 30–40 |
| 3/32 in. | 45–60 | 35–50 |
| 1/8 in. | 90–110 | 80–100 |
| 5/32 in. | 130–150 | 110–130 |
| 5/16 in. | 150–170 | 130–150 |

## ANTI-FOG PREPARATION

A new anti-fog preparation for keeping goggle lenses, face shields and welding plates clear is announced by the American Optical Co., Southbridge, Mass.

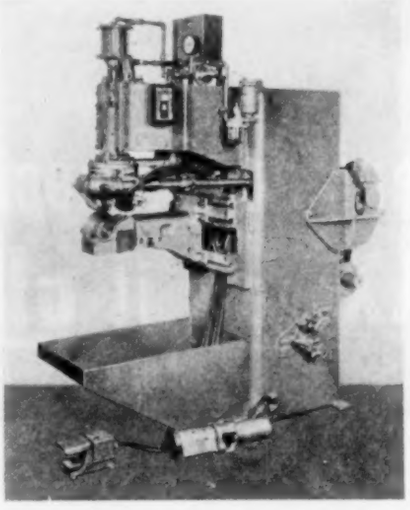
Fog on lenses, the concern points out, is annoying—but, more important, it is actually dangerous since it obscures vision and increases accident frequency.

The new AO anti-fog material, made from a scientific formula to penetrate the ultramicroscope pores of glass, deposits a thin film which helps prevent fogging, steaming and frosting of all types of glass surfaces. In addition, it removes grease and dirt from glass, and allows perfect visibility.

The preparation is easily applied by simply spreading it on both surfaces of glass, rubbing the surfaces thoroughly, and then polishing them with a soft cloth or paper. The anti-fog preparation is obtainable in a 1-oz. jar or a 1-lb. jar.

## LIGHT DUTY SEAM WELDER

Thomson-Gibb Electric Welding Co., Lynn, Mass., has just introduced a new Thomson seam welder, known as the Model 6, for work ranging from 30 to 18 gage clean, mild steel in two thicknesses. Production speeds range up to 20 ft. per min.



Like the heavier duty seam welders this model is capable of a wide range of application. It may be employed for circular or for longitudinal welds, or as a universal machine with swiveling upper head and interchangeable lower arm (as shown in the picture) for ready and rapid conversion from circular to longitudinal seaming. It is available in various throat depths and transformer capacities to suit the work.

The welding wheels may be gear or knurl driven and the drive may be applied to either the upper, or lower, or both wheels.

Shown in the picture are the worm reduction, motor drive and the series-parallel 16-point heat regulator. Separate water cooling circuits are provided for the transformer, upper welding shaft, head, lead bracket, lower welding arm and bracket.

Electronic current timing control permits a wide range of work and assures uniform, rapid and economical production.

## HARD-FACING ALLOYS

There are many pieces of wearing equipment whose life is destroyed by heat, corrosion, impact or abrasion, or a combination of several of these factors. With the development of Stoody 1 and Stoody 6, two nonferrous hard-facing alloys for oxyacetylene application, life of these parts was increased from three to ten times.

There are, however, numerous applications for wear-resisting metals of this type which cannot be satisfactorily hard faced with oxyacetylene equipment, such as heavy equipment wherein welding economy becomes a factor, or intricate shapes where heat treatment or desirable physical properties of the base metal may be destroyed by the torch flame.

For these applications Stoody Co. now offers two new hard-facing alloys for electric application, viz.: Coated Stoody 1 and Coated Stoody 6. A special dipped coating makes application easy with either a.-c. or d.-c. electric equipment, and at the same time protects the alloying elements so that weld deposits are produced having the same analysis and physical properties as those applied by the oxyacetylene torch.

Typical applications are as follows: vegetable and fish oil expeller parts, heavy hot punches, capstans, heavy blades for cutting scrap or shearing hot steel, blast furnace bleeder valves, blowing engine gas valves and seats, heavy mill guides, hot trimming dies, blanking dies, forming dies, stoker screws, coke oven push shoes, hot clinker conveyor screws, etc. Stoody Co., Whittier, Calif.

## WELDING POSITIONER

The "Standard" Welding Positioner is designed to fill the need for a reasonably priced—completely powered—entirely enclosed—multi-purpose machine which will provide easy and positive control of the rotation, elevation and tilting of work up to 700 lb.

Beside its superiority for both production and job welding, the machine has proved adaptable for moving work past the torch and quench in flame-hardening operations. The table can be removed easily and various jigs attached directly to the elevating screw. Also, work may be mounted on the table and set quickly at any angle with worker to facilitate inspection and assembly operations.

The Positioner is provided with the new built-in "Standard" variable speed transmission and hydraulic cylinder for definite power control with a single 1/2-hp., 110-, 220- or 550-v. electric motor so that linear speeds from 1 to 180 in. per minute are easily set and regulated. There are no belts or clutches—reversing is instantaneous. Standard Machinery Co., Providence 7, Rhode Island.

## ELECTRIC IDLING DEVICE

To save gasoline and prolong engine life, a new mercury-type Idling Device which automatically shuts down the gasoline engine to idling speed 12 to 15 sec after the operator has stopped welding is announced by The Hobart Brothers Co., Troy, Ohio.

To bring the engine to normal welding speed, the operator merely strikes an arc. The idling device and governor are linked with the throttle in such a manner that the device can close the throttle without hav-

IF YOU DO

# Production Welding or Brazing

## *investigate* EUTECTIC RODS AND FLUXES

## *Low Temperature** Welding

**For production work, an ever increasing number of leading manufacturers are now using EUTECTIC Rods and Fluxes in place of fusion welding, brazing and silver soldering, because the EUTECTIC Low Temperature* Process affords them new economies and additional advantages over conventional welding methods. Not only are many of the most difficult problems solved through the application of EUTECTIC Rods and Fluxes but ordinary welding jobs are performed at lower cost by means of this revolutionary process.**

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**By means of 48 specially developed Rods and Fluxes the many advantages of EUTECTIC Low Temperature* Welding can be employed to join all metals. Every standard method of heating such as Gas — Arc — Induction and Furnace can be used since EUTECTIC Low Temperature* Rods and Fluxes are supplied in rod, wire, strip and powder form to meet all requirements.**

**If you have tough metal joining problems or are planning new production, NOW is the time to investigate EUTECTIC Low Temperature* Rods and Fluxes by calling in your local EUTECTIC Field Engineer who will gladly help you. In the meantime, why not order the all-round selection of 9 important EutecRods for your current work and experimental jobs. Mail the coupon, or write on your company letterhead.**

***EUTECTIC solves tough welding problems and makes routine jobs easier. Try it today!***

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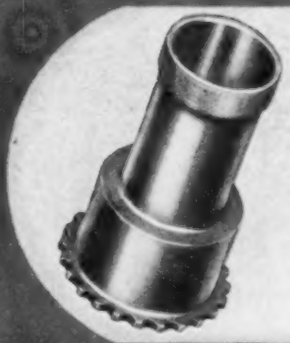
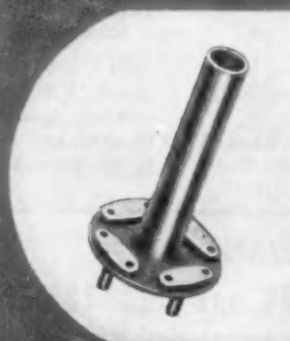
**Bronze castings welded with EutecTrode 28. This is the first electrode developed that can successfully weld copper, brass and bronze with an AC-DC metallic arc. Completely machinable, perfect color match; high tensile strength.**

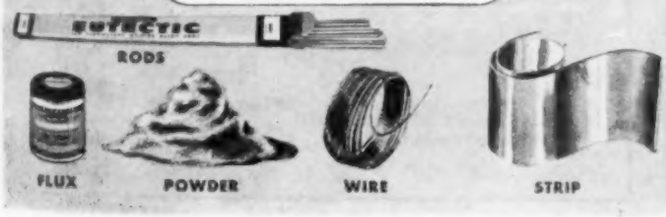


**Steel sprocket gear welded with EutecRod 16. Carloads of steel were saved by simplifying the design of this machine part. Separate components were welded together with high tensile EutecRod 16.**



**Aluminum tubing washer and four aluminum screws assembled with EutecRod 190. Note that on thin aluminum sections, welds made with this alloy minimize distortion. This costly forging was produced by welding together aluminum components—a testimonial to the speed and qualities of EutecRod 190.**

*Castolin Eutectic*

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ORIGINATORS OF EUTECTIC LOW TEMPERATURE WELDING

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Company.....

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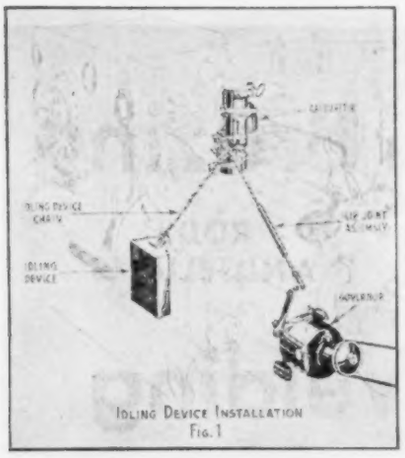
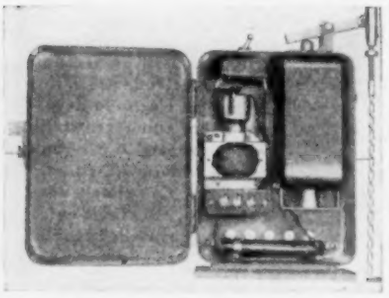



IDLING DEVICE INSTALLATION
FIG. 1



MERCURY TYPE IDLING DEVICE

ing to resist the governor action. When welding, the governor controls the engine speed without any interference from the idling device. The device can be made inoperative by opening an off-and-on toggle switch without affecting the welder or gasoline engine operating characteristics.

## ALL-PURPOSE ELECTRODE

The Champion Rivet Co., Cleveland, Ohio, who this year celebrated their 50th Anniversary, announce their new A.W.S. 6011 electrode known as Champion BLUE-DAC. This electrode has been tested and approved by the American Bureau of Shipping and The Lloyds Register of Shipping under the new specifications A233–45 T for electrodes prepared jointly by the A.S.T.M., and A.W.S. It is suitable for welding in all positions with a.-c. current, or d.-c. reverse.

The Champion line includes mild steel electrodes, high-tensile electrodes, stainless steel electrodes and a complete list of welding accessories.

## BRAZING ASSEMBLY

A saving of 13 cents per part on standard cam followers was made possible through the adoption of a two-piece copper brazing assembly method at The Glenn L. Martin Co., Baltimore, Md. Prior to this time the cam followers had been machined in one piece from solid steel bar stock.

The assembled part consists of a rectangular flange with small tubular projections at each side from the center hole of the flange.

In the old method the followers were "sculptured" from round bar stock on a screw machine. The parts were roughed out, finished to the proper diameters and the center hole was drilled and reamed. Two small holes in the flange for attaching the part of its next assembly were then drilled and burred. Another operation was required to blank off both sides of the round flange to make it rectangular.

Using the brazing method, the cylindrical portion of the assembly is a piece of stock steel tubing, which is sized to the proper diameter for brazing and cut off in the screw machine. The rectangular flanged portion is blanked from strips of

Rings of Copper Brazing Material Are Slipped Over the Assemblies on the Part Holder. After the Assemblies Are in the Furnace, the Copper Melts and Is Drawn Into the Joint by Capillary Attraction

steel stock by a progressive die. The round hole in this rectangular piece through which the cylinder passes is blanked and sized to proper dimensions in the same operation. Proper dimensions are essential to ensure a satisfactory brazing fit.

For brazing, the cylindrical portion is slipped into the hole in the flange after which the assembly is placed on a part holder and the rings of copper brazing are placed on each assembly at the joint. The parts holder is loaded with the assemblies and placed in an electric brazing furnace. During the brazing process the copper ring melts and creeps into the joint by capillary attraction, resulting in a strong clean joint.

After brazing, manufacturing procedure to finish the parts is the same as in the prior method. The two attaching holes are drilled and burred, the cam portion profiled by milling and the edge hardened by induction heating.

During tests the new type followers were found to have strength beyond any previous design requirements.

## ALL-PURPOSE ELECTRODE HOLDER

This new electrode holder offers many practical improvements in design to increase welding efficiency by 20%. It is fully insulated, and known as the Garibay "350." It is light in weight (17 oz.), simple and compact for ease in manipulation. Carries 350 amp. continuous conductivity. Offset jaws provide a full view of work at all times, making welding pos-

**WE WANT**

**MACHINE DESIGNERS and DRAFTSMEN**

for development, design, layout and detailing of special and experimental industrial machinery. Men with creative ability preferred, experienced in electrical, hydraulic and pneumatic application. Only persons with well-founded practical experience should apply. Permanent positions with good salaries and opportunities for advancement in a growing organization are possible for those who qualify. All replies confidential. Address J. F. Joy, Vice-President-Eng'g. The Federal Machine & Welder Company, Warren, Ohio

*NET MONTHLY ADVERTISING RATES*

*Black and White* *Effective April 1943*

| Space | One Insertion | Three Insertions | Six Insertions | Twelve Insertions |
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| *Full Page | $120 | $105 | $95 | $85 |
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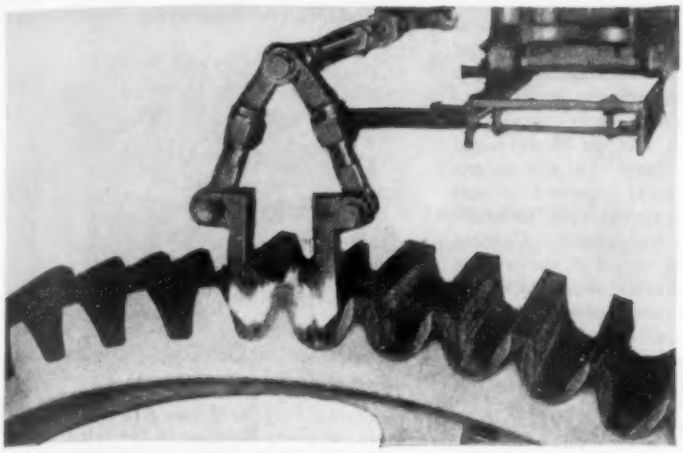
| Quarter Page | 42 | 38 | 35 | 30 |
| Eighth Page | 30 | 25 | 20 | 18 |
| *Inside Preferred | 135 | 120 | 110 | 100 |

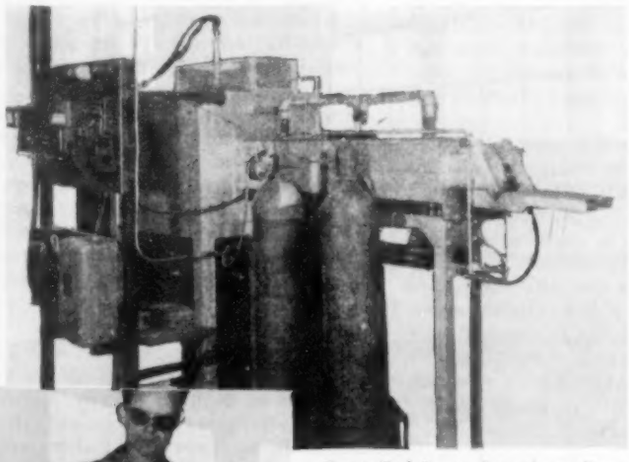
*10% Extra for bleed full pages. Color $40 Extra per color added

# Better Metal Parts Faster



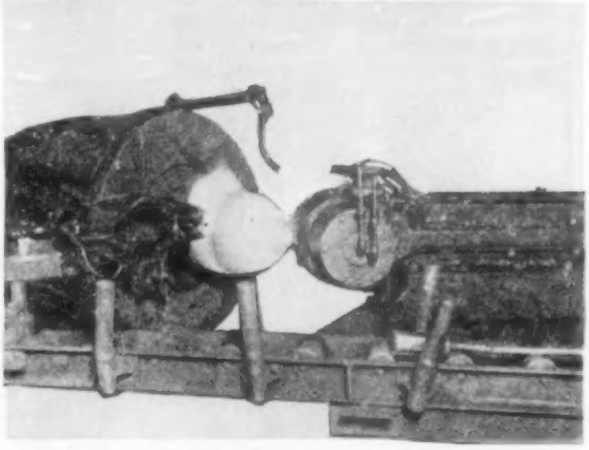
**Flame Hardening.** Using special flame hardening tips, as in the case of this gear, surface hardening can be confined to areas of parts subject to wear or abrasion. Quench spray follows immediately after the heating torch reducing time at heat to the minimum. Warpage is minimized and grain structure and ductility of untreated areas are unchanged. Using a slightly carburizing flame, surface decarburization is held to a minimum and little or no finishing after hardening is required. (Note even penetration of hardness in the photo above.)

**Flame Descaling.** This simple Airco process, using the oxyacetylene torch with special tips, quickly and thoroughly removes furnace scale from heat treated, annealed and normalized parts. The heat of the torch causes the scale to expand and pop off the relatively cool surface of the parent metal.



**Controlled Atmosphere Annealing.** Use of Airco high-purity nitrogen in controlled atmosphere annealing of metals of all kinds assures highest satisfaction.

**Flame Heating for Bending.** The oxyacetylene torch with special multiple heating tip presents unlimited possibilities for heating metals for bending and otherwise shaping where suitable furnace equipment is not at hand.



**Flame Spinning.** In spinning this bomb, the heat of the oxyacetylene flame keeps the metal at proper plasticity throughout the forming operation.

**OTHER AIRCO PROCESSES SERVING THE METAL-WORKING INDUSTRIES**

**Machine Gas Cutting, Arc Welding, Plate Edge Preparation for Welding, Low Temperature Brazing, Braze Welding, Helium-Shielded Arc Welding, Pipe Welding, Hardfacing, Flame Nicking of Billets, Flame Cleaning and Dehydrating, Flame Gouging, Hand Gas Cutting**

# AIR REDUCTION

General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

In Texas: MAGNOLIA AIRCO GAS PRODUCTS CO. • General Offices: HOUSTON 1, TEXAS

*Offices in all Principal Cities*

sible in places ordinarily inaccessible. It uses all the coated portion of the electrode. Bending of the rod and breaking the flux are never necessary. Full throat construction provides easy flow of electricity with a minimum of resistance. Scientifically ventilated for cool handling. Equipped with a mechanical cable connector which does away with the slow solder method.

Write Yarco Distributors, 215 West 7th St., Los Angeles 14, Calif., or 120 Wall St., New York 5, N. Y.

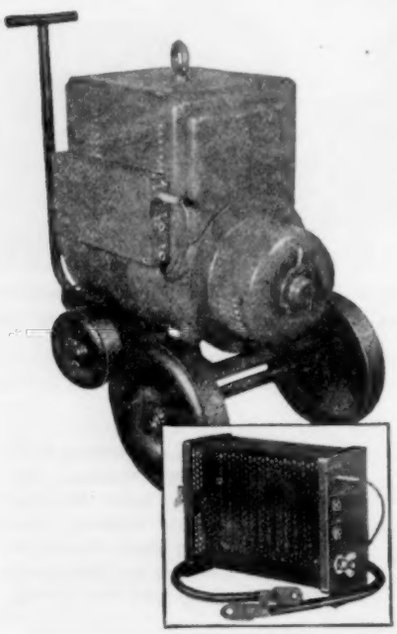
## LIGHT GAGE WELDING

A new 3-step Thinweld attachment that gives wider range to standard arc-welding machines and makes it possible to weld from 10 amp. up through the maximum rating of the welding machine without any dead spots in the complete welding range is announced by The Hobart Brothers Co., Troy, Ohio.

This is an ideal attachment for arc-welding machines being used in widely diversified fabricating plants and job shops where the work may vary from extremely heavy to the lightest gages practical for welding.

The No. 413 Thinweld attachment is furnished with a 3-ft. cable which is connected to the ground terminal of the welding machine and the ground lead is connected in turn to the wing nut on the Thinweld.

When installed on Hobart arc welders at



THINWELD ATTACHMENT

the factory, the No. 412 Thinweld installation is attached permanently on the back of the welding machine and is connected to the first and second range of the ten range switch. Thus, in the first range, the 3-step Thinweld permits additional lower amperage for light-gage welding and the other ranges from two to ten give the operator the wide range of higher amperage for welding of the heavy gages.

## CUTTING ELECTRODE

A new and vastly improved type of cutting Electrode, permitting greatly increased speed in metal cutting and for use at unlimited depths underwater, has been released by the Ellwood Products Corporation, Ellwood City, Pa. So designed that any skilled workman can successfully cut metal after only ten minutes instruction, the Ellpro Electrode was developed primarily to permit salvage of damaged ships by the U. S. Navy, that are endangered by large masses of bent and twisted armor plate which prevent their proceeding to navy yards for repairs. Cutting away the extruding material means the ships can return to harbor under their own power for complete overhauling.

The Ellpro Electrode is made of steel in the form of a hollow tube with an adhesive type coating which prevents it from sticking to the cutting surface. It is used with oxygen, which permits safety to the user at any depth underwater, whereas other methods of cutting become dangerous as the depth and pressure increase.

The adhesive coating was developed through cooperation, research and exhaustive testing with the U.S. Naval Engineering Experiment Station at Annapolis and the Minnesota Mining and Manufacturing Company. Over two years were spent in experimentation on hundreds of different types of coatings and the adhesive type most successfully met all requirements under the most difficult conditions. The Ellpro Electrode, with this coating, has been in production for some time and is the latest design offered for use in industry.

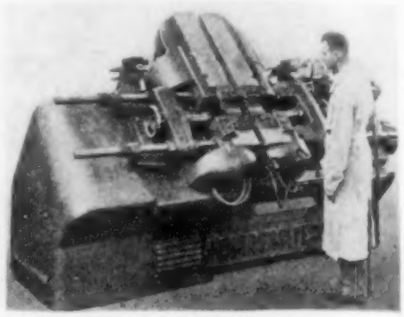
Speed of operation is a major advantage of the new Ellpro Electrode; a molten arc is obtained the instant it is placed against the surface to be cut. It can be used successfully underwater or anywhere on land, with either a.-c. or d.-c. current. A torch holder, perfected for use with the Ellpro Electrode, prevents it from burning down to a point where it cannot be removed with ease. As cutting life ends, it can simply be drawn from the holder and a new one inserted with practically no loss in time.

Although the Electrode was designed primarily for underwater cutting, it is easily adapted to cutting scrap iron or steel, salvaging sunken marine equipment and rehabilitation work in war-torn cities and towns. Since no particular skill is needed, many other applications in bridge, dam, building and highway construction are foreseen for post-war use.

Further details and engineering data on the Ellpro Electrode can be obtained from this publication or by writing directly to the Ellwood Products Corporation, Ellwood City, Pa.

## NEW LINE OF FLASH WELDING MACHINES

Development of an entirely new line of butt-flash welding machines in five standard sizes embodying numerous new design and operating features to provide maximum flexibility as to application, ease of maintenance and operation, safety and reliability—has been announced by Progressive Welder Company, 3050 E. Outer Drive, Detroit 12, Michigan. The machines range in electrical capacities from 20 kva. to 250 kva. The five basic sizes, which comprise this range, are classified and rated according to recommended specifications of the Resistance Welder Manufacturers' Association.



**The Striking New Line of Progressive Flash Welding Machines Are Built in Five Standard Sizes Ranging in Electrical Capacities from 20 Kva. to 250 Kva.**

One of the numerous outstanding features of the new Progressive line of flash welders is the full hydraulic operation through a single self-contained hydraulic unit available on the larger models. In these, the unit is mounted within the frame of the machine and can be removed without disassembly for inspection or service. It contains three pumps: (1) a rotor blade pump for platen traverse, (2) a gear type pump for clamping the work to the electrodes; and (3) a piston pump to furnish pressure for the upset action.

The design and construction of the new Progressive flash welding machines enables the ready mounting of all manner of special horizontal and vertical acting clamping fixtures and tooling to allow for wide variations in sizes and shapes of work encountered in the field—which may be welded interchangeably on these standard Progressive machines. All clamping fixtures are fully adjustable in two planes, permitting universal alignment.

Use of a single hand lever, with a push button for control of welding current mounted at its tip, enables the operator to control all stages of the welding cycle from one position. The rate of platen travel follows the movement of the hand lever in both forward and reverse directions, and both this rate and the position of the platen are indicated on a large calibrated dial opposite the operator.

Manual control of flash and upset operations is by movement of the hand lever to the left and pressing the push button to initiate and maintain the welding current. Upset pressure is applied during the latter part of the lever travel by preset cam action. Return of platen after welding is accomplished by moving the hand lever to the right.

Full automatic control is initiated by pressing the platen traverse button. The machine then carries through the approach, flash and upset, and return cycle.

Semi-automatic control provides manual approach with automatic flash and upset. During any phase of either type of control the platen travel may be stopped or reversed by moving the hand lever. Additional push buttons are provided for control of feed, motor on-off and weld, no-weld at the operating position.

# Eliminates drilling and tapping studs—

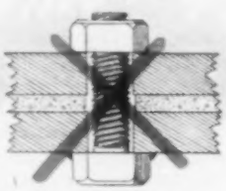
# NELSON ARC STUD WELDING!

**Automatic stud welding** saves time and material. It eliminates the costly operations of drilling, tapping, and hand welding bolts for studs. With the Nelson Stud Welder "flux-filled" studs are *automatically* end-welded to metal instantly. Uniform welds with full-fillet result every time.

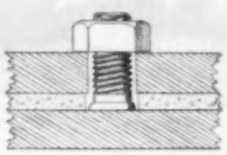
All standard stud diameters from $\frac{3}{16}$" to $\frac{3}{4}$" are manufactured—all may be welded with the same stud welding unit. A standard welding generator is used. The equipment is portable and may be used effectively in any position or operated as a production unit from a fixed jig. (Multi-gun units are available for special production jobs.) More than 700 industrial plants and shipyards are using thousands of stud welders in time-saving applications. No previous welding experience is necessary for operators.

*The Nelson Stud Welder welding through locating template.*

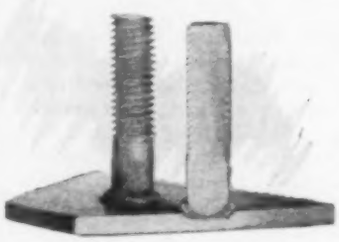
## STUD WELDED IN ½ SECOND!



**Eliminates** hand welding to secure bolt or stud. Unsightly bolt head is omitted.



**Instead** stud is welded to metal—equal in strength yet saves three or more operations!



*Cutaway view of stud weld after etching with Nital.*

**Complete fusion** of stud to metal is obtained—a deep penetration. Fillet not only on outer surface of stud but complete binding through base. Automatic timing control and uniform heat produces these results—consistently and quickly.

*For complete details, prices and catalog write:*

NELSON SPECIALTY
WELDING EQUIPMENT CORP.
**Dept. J, 440 Peralta Avenue**
**San Leandro, California**

*Eastern Representative: Camden Stud Welding Corp. Dept. 122, 1416 South Sixth Street, Camden, N.J.*

## FLUX

"Flo-Well" No. 1, an improved free-flowing flux for the gas welding of aluminum and aluminum alloys, is now being manufactured by A. K. Mauk, 7542 Hamilton Ave., Pittsburgh 8, Pa.

Flo-Well is used to gas weld wrought, cast or high-tensile aluminum and aluminum alloys, of any size or shape, wherever welding is possible. As a result of improved methods of manufacture, Flo-Well will positively not solidify or deteriorate. It can be easily applied by inexperienced welders.

Flo-Well Is Easily Handled and Quickly Applied

Flo-Well, which is being widely used by the aviation and other industries, is packaged in 1/4- to 25-lb. glass containers to protect the flux from moisture. It may also be purchased in ton lots. Free samples and instructions for use of this flux, will be forwarded by the manufacturer upon request.

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## "TUFANHARD" ELECTRODE

A new heavy coated hard surfacing electrode that welds like mild steel and "wears like a diamond" has been developed by the Hobart Brothers Co., Troy, Ohio. This new electrode, designated as "Tufanhard" is made in three grades, "600," "400" and "250" which corresponds with the Brinell hardness of deposited metal.

While "Tufanhard" produces a hard alloy weld, it has all of the ease and smoothness of operation ordinarily attributed to a heavy coated mild steel rod. It can be used in all positions with no more skill than is required by the so-called "cold" rod. The welds can be made continuously with overlapping beads without the necessity of removing the slag, and the low spatter loss and smoothness of bead requires only a small amount of grinding in finishing, making it very economical to use. The deposit can be heated and drawn to any temper within the range of the type rod used.

Hobart "Tufanhard" will operate on either alternating or direct current, straight polarity being recommended when using d.-c. machines. Electrodes are made in 14-in. lengths, in 1/8-, 5/32-, 3/16- and 1/4-in. sizes and packed in 5- and 25-lb. cartons.

## NEW THREE-PURPOSE WELDING ELECTRODE

A new combination type welding electrode, Airco No. 315, designed to produce horizontal fillet welds with flat or slightly concave profiles and concave fillets in the flat position, as well as satisfactory deep fillet and deep groove, has been announced by Air Reduction.

Usual applications for the new electrode include pressure vessels and their connections, heavy machine weldments, structural assemblies such as trusses, built-up girders and connections and practically all heavy steel assemblies where high weld quality is important.

Airco No. 315 electrode is recognizable by its steady, forceful spray type arc. The thick porous slag which completely covers the weld deposit under practically every condition is readily removed. The electrode may be used with conventional technique, employing normal currents, under which conditions medium penetration is obtained. Deeper penetration is secured, however, when the deep fillet technique is used with the high currents recommended for this procedure. The new Airco No. 315 can be used for any job that calls for a 6020 or 6030 electrode and may be applied with either the alternating or direct current, straight or reverse polarity.

Further data are available on request from Air Reduction Sales Co., 60 East 42nd St., New York 17, N. Y., or any local Airco office.

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## THEISINGER PROMOTED

William G. Thesinger, who has been Director of Welding Research at Lukens Steel Company, Coatesville, Pa., since February 1941, has been appointed Assistant to Vice-President, it was announced today by D. S. Wolcott, Vice-President of the company. Dr. Thesinger will assist Mr. Wolcott in work connected with the manufacture, sale and application of special products such as clad steels.

Dr. Theisinger joined Lukens in August 1935 as Welding and Metallurgical Engineer and has specialized in the handling of technical matters involved in the application, fabrication and sale of the company's products.

Dr. Theisinger was born in April 1904, in Carlisle, Pa. After attending Harrisburg public schools, he became Assistant Chemist at Harrisburg Steel Corporation. In 1925 he became associated with the Board of Transportation of the City of New York in the development of welding inspection.

In 1930, Dr. Theisinger matriculated at Harvard University receiving the degree of Bachelor of Science in 1934. That summer he served the Western Pipe and Steel Company as Consulting Engineer on high amperage, automatic welding. In 1935, after completion of post-graduate work at Harvard, he received the degree of Doctor of Science.

Dr. Thesinger is a member of the AMERICAN WELDING SOCIETY, the American Institute of Mining and Metallurgical Engineers, the American Branch of the Newcomen Society of England, the Franklin Institute and the Harvard Club of N.Y.

## ANNUAL MEETING PROGRAM

As announced previously the AMERICAN WELDING SOCIETY will confine its Annual Meeting Program to a one-day session on Thursday, October 18, in New York. The morning will be given over to the Award of Medals and Prizes and the Adams Lecture by Dr. S. L. Hoyt of Battelle Memorial Institute, on "Selection of Steel for Welding."

In the afternoon there will be the regular Business Meeting of the A.W.S. and the Installation of new Officers. Following this there will be a meeting of the newly elected Board of Directors.

In the evening, the New York Section of the A.W.S. will celebrate its 25th Anniversary by holding a Dinner Dance at the Hotel Pennsylvania, New York. An outstanding speaker will be selected for the occasion. Ladies are cordially invited to attend. Price of the tickets is $6.00 per person. These may be purchased from Mr. H. O. Klinke, Air Reduction Sales Co., 181 Pacific Avenue, Jersey City, N. J., or Mr. George Schneider, Acetylene & Welding Equipment Co., 1065 Atlantic Avenue, Brooklyn, N.Y.

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## SECTION NEWS

With the lifting of some of the restrictions against the use of paper THE WELDING JOURNAL will resume publication of Section Activities and New Members in the October issue.

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# Employment Service Bulletin

## POSITIONS VACANT

V-172. Long-established New Jersey Machinery Manufacturer wants two Regional Managers: one for Eastern Area; one for Central Area, to call on established distributors and customers. Experience in selling welding equipment preferable, but not essential. Excellent postwar possibilities. In replying give experience and statement of availability.

V-173. Welding Engineer for progressive expanding welding factory; with technical background, capable of supervising production; experienced in all phases of gas and arc welding of lighter gage metals; familiar with spot welding aluminum and induction brazing; able to design jigs and fixtures for production. Excellent postwar opportunity. Write details and background, experience and salary.

V-174. Production Superintendent or Engineer familiar with processes involved in fabrication of stainless steel tanks of large capacity. Must have knowledge of stainless steel welding, insulation and refrigeration relative to storage of perishables in these tanks. Forward abstract of business and personal history. Salary open.

## SERVICES AVAILABLE

A-502. Welding Supervisor with many years of laboratory, shop and construction experience. Knowledge of foreign languages.